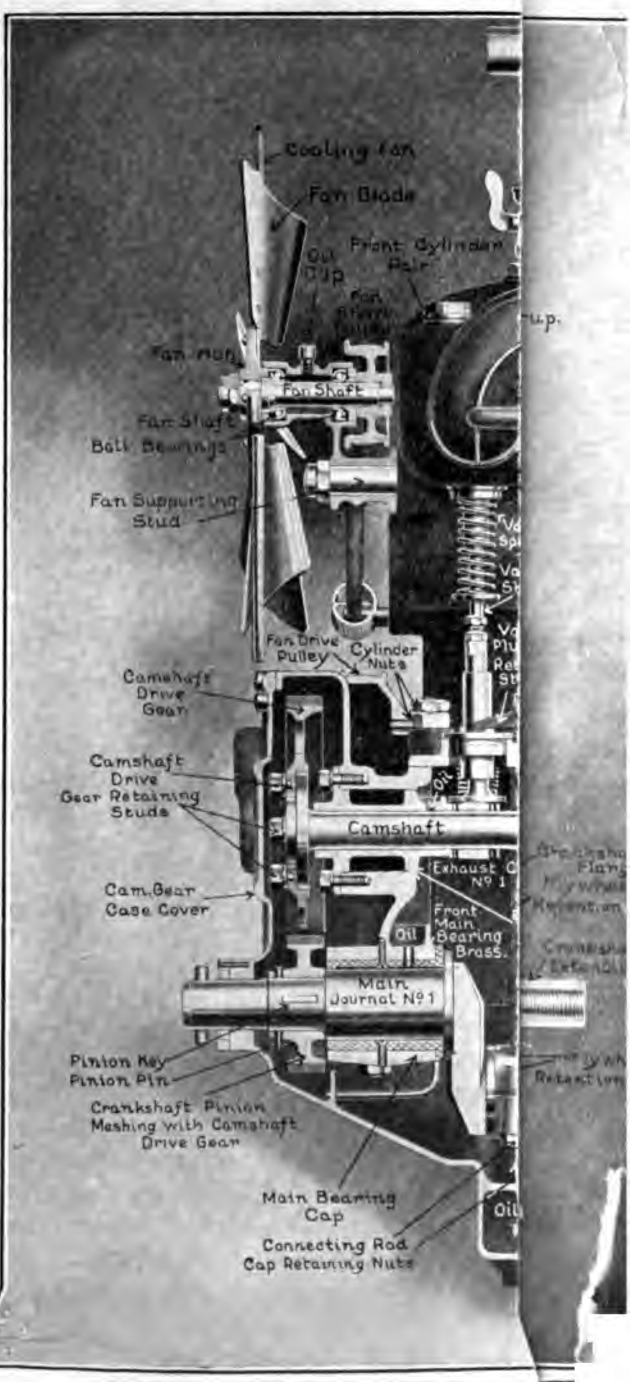
[redacted]

[redacted]


Cooling Fan
Fan Blade
Oil Cup
Front Cylinder Pair
Fan Hub
Fan Shaft
Fan Shaft Ball Bearings
Fan Supporting Stud
Fan Drive Pulley
Cylinder Nuts
Camshaft Drive Gear
Camshaft Drive Gear Retaining Studs
Cam Gear Case Cover
Oil
Camshaft
Front Main Bearing Brass.
Oil
Main Journal Nº 1
Pinion Key
Pinion Pin
Crankshaft Pinion Meshing with Camshaft Drive Gear
Main Bearing Cap
Connecting Rod Cap Retaining Nuts
Oil

UTOMOBILE REPAIRING MADE EASY

IOP METHODS — EQUIPMENT — PROCESSES

A COMPLETE TREATISE
PLAINING APPROVED METHODS OF REPAIRING ALL PARTS
ALL TYPES OF GASOLINE AUTOMOBILES. SHOWS ALL LATEST
VELOPMENTS BASED ON A WIDE, ACTUAL REPAIR EXPERIENCE

Includes
ectric Starting and Lighting System Instructions; Oxy-Acetylene Welding; Tire Repairing; Engine and Ignition Timing; Overhauling, etc.

INVALUABLE TO MOTORISTS, STUDENTS, MECHANICS AND REPAIR MEN
EVERY PHASE OF THE SUBJECT IS TREATED IN A
PRACTICAL, NON-TECHNICAL MANNER

BY
VICTOR W. PAGÉ, M. E.
Member Society of Automobile Engineers
thor of "The Modern Gasoline Automobile," "Automobile Questions and Answers," "The Ford Model T Car," etc.

Illustrated by Over 1000 Specially Made Engravings

E ILLUSTRATIONS DEFINING CONSTRUCTION OF PARTS ARE MADE FROM
ACCURATE AUTOMOBILE ENGINEERING DRAWINGS

NEW YORK
E NORMAN W. HENLEY PUBLISHING COMPANY
2 WEST 45th STREET
1918

THIRD IMPRESSION

NOTE.—All illustrations in this book have been specially made by the publishers, and their use without permission is strictly prohibited.

Printed in the U. S. A.

PRESS OF
BRAUNWORTH & CO.
BOOK MANUFACTURERS
BROOKLYN, N. Y.

PREFACE

The rapid growth of the automobile industry has resulted in a marked increase in the number of automobile repair shops and, as the sale of cars augments yearly, the demand for mechanics skilled in the art of caring for, adjusting and repairing automobiles will continue to grow in proportion. Then again, many cars are purchased by people in moderate circumstances or others remote from repair shops who desire to make their own adjustments and minor repairs. Many excellent mechanics in other lines have felt that the automobile business offered opportunities, but were unable to avail themselves of them because of lack of knowledge of motor car construction.

The writer obtained much practical knowledge of automobile mechanism first hand as a repairman in the earlier days of the automobile industry and often felt the lack of definite, scientific instructions for doing various classes of work in a practical manner. When one considers that the modern automobile is a complex assembly of many different groups, it is not difficult to understand why an excellent machinist, for instance, may be unable to repair a starting and lighting system because of lack of electrical knowledge, or why the electrician, to whom this work is not difficult, may be unable to refit bearings or time a motor valve system. The practical all-around automobile repairman must not only understand machine work and metal-working tools of all kinds, but must also possess some of the knowledge of the electrician, plumber, wood-worker, rubber-worker, tinsmith and blacksmith.

It is the purpose of the writer to outline the essentials of automobile repairing in a way that will be understood by all with ordinary mechanical ability. Much of the material will prove of equal value to the chauffeur, owner and general mechanic. The writer has been collecting notes and sketches for this treatise for over eleven years and has had an exceptional opportunity to sup

plement the practical knowledge obtained as a repairman by careful observation of the experiences of others.

With the object of outlining the entire subject, the various iten of equipment, tools and special appliances to facilitate repair wor are covered fully and a concise review of the various mechanic processes, such as autogenous welding, brazing, soldering, etc., i given as well. Many Tables and Formulæ are included pertainin to things the repairman should know or have available for read reference. Special attention has been given to the electrical systen because it is on this point that many repairmen and motorist desire enlightenment. It is assumed that the reader is familiar t a certain extent with automobile construction in general. If infor mation is wanted on points of design, etc., the reader is referre to "The Modern Gasoline Automobile," a previous work of th writer.

As many establishments are being started from time to time t care for the increasing number of motor vehicles sold, some sugge tions for planning and equipping various sized shops should b timely and of value to those intending to start such an enterpris There are many conditions to be considered, and no hard or fas rule can be made to cover all contingencies. The equipment neede to do work in a most satisfactory manner will vary with the size o the shop and character of cars repaired. The writer will confin this discussion to useful suggestions that can be applied specificall to the machine or other shop that specializes in repair work.

Most of those outlined have no facilities for doing a garage o storage business, but the plans may be modified and applied to shop operated in connection with a garage or agency for cars as wel While the equipment proposed is most comprehensive in the case o the larger establishment and sufficient to build all parts of a moto car if necessary, the facilities may be increased or reduced as th capacity of the shop requires. In planning a new shop or enlargin a business, some of these suggestions may be of value, and it is we to note that proposals made for tools or equipment and floor plan described are based on actual experience of successful shops.

THE AUTHOR.

February, 1918.

CONTENTS

CHAPTER I

THE AUTOMOBILE REPAIR SHOP

CHAPTER II

SMALL TOOL EQUIPMENT FOR REPAIR SHOPS

CHAPTER III

OVERHAULING THE GASOLINE ENGINE

CHAPTER VI

MOTOR STARTING AND LIGHTING SYSTEMS

CHAPTER VII

DEFECTS IN CLUTCH AND GEARBOX

CHAPTER VIII

FAULTS IN CHASSIS COMPONENTS

CHAPTER IX

THE REAR AXLE AND DRIVING SYSTEM

CHAPTER X

WHEELS, RIMS AND TIRES

CHAPTER XI

MISCELLANEOUS REPAIR PROCESSES

CHAPTER XII

USEFUL INFORMATION FOR AUTO REPAIRMEN

CHAPTER XIII

HINTS AND KINKS

CHAPTER XIV

USEFUL TABLES FOR THE MECHANIC

Mathematical Tables

Mechanical Tables

Miscellaneous Tables

AUTOMOBILE REPAIRING MADE EASY

CHAPTER I

THE AUTOMOBILE REPAIR SHOP

Requirements of Buildings Utilized—Lighting Methods—Heating and Ve tilation—Arrangement of Departments—How Raw and Finished Sto Is Stored—Planning Small Shop—Arrangement of Medium Size Sh —Typical Large Service Station—Assembling Room Equipment Bench Construction—Bench Furniture—Assembling Room Furniture Pit Construction—Turn Tables—Lifting and Moving Appliances—Mach: ery Equipment for Small Shops—Equipment for Complete Machine Sh —Power for the Shop—Electric Power—Small Generating Sets—The G and Gasoline Engine—Power Needed for Various Machine Tools—Inst lation of Machine Tools—The Lathe Types and Accessories—Shape Planers and Drilling Machinery—Miscellaneous Appliances—Air Compr sor Equipment—Fuel Storage Methods—Shop Forge Equipment.

The care and maintenance of automobiles is one of the mc important branches of this large industry and as great advanc have been made in the erection and equipment of establishmen for repairing these vehicles as in the design of the automobil The equipment of a service station will vary from a very simp tool outfit of the small shop mechanic to the more expensive i stallation found in metropolitan service stations. Many speci appliances have been evolved, especially for automobile repairi and special tools and fixtures have been contrived by the ingenio mechanic to simplify repair work. Before describing the pr cesses incidental to the repair of the various motor car componen the writer believes that a discussion of the equipment needed f repairing will prove of value to those who are about to erect a automobile repair shop or service station, as well as to those wl plan to increase present more or less limited facilities. Sever

important points that are apt to be neglected by the average archi tect in designing a garage or repair shop building will be co sidered first and then the equipment of tools, supplies, and speci appliances necessary to furnish the repair shop in a first cla manner will be discussed.

Requirements of Buildings Utilized.—Structures that ha been used in another business do not always give full satisfacti when remodelled and equipped for motor car repairing. The o general fault all of these buildings have is inadequate lightin facilities, and they are seldom properly heated or ventilated. Lar wooden structures formerly used for carriage or wagon shops, live stables, etc., are often utilized, but these are invariably very i flammable, which alone should condemn them, even if the prop lighting and heating facilities were installed.

Many buildings have been erected for repair shops or garag that are lacking in conveniences not included because of lack experience on the part of architects or builders, who do not unde stand the requirements of the repair business. These buildin obviously could be improved in arrangement and even in detai of construction by those familiar with the restoration of aut mobiles and their component parts.

Any structure used for motor car housing or in repair wo should be absolutely fireproof, which means that only materi having the desired qualities, such as steel, brick, stone or concre be incorporated in the construction, with a minimum of woo The building should not be more than two stories high, if the lan is available, though large establishments in the heart of big citi will have to be three, four or five stories in height, depending up the size of the lot available, the floor space needed and the prevai ing prices of real estate. If it is to be operated in connection wi a garage business on the same premises, the repair shop should l in the second story, the storage room on the ground floor.

In any event, the point of using natural to the exclusion artificial light cannot be too firmly impressed on the builder. M chanical work of all kinds demands the best of light, and in tho buildings utilizing daylight in preference to electricity or oth source of illumination, not only is the work carried out bette

ut a large item of expense, which must be included in the fixed harges of operation, is eliminated. The best construction, and one hat has been demonstrated to be thoroughly practical in large, modern manufacturing establishments, is a steel framework, with concrete walls pierced by many large windows, and a sawtooth roof. The advantages of this construction over that using ordinary skylights is that the sun cannot shine in directly to interfere with the work, as the openings point toward the north, a stronger roof having more openings for light is obtained, and there is no possibility of water leaking in. What is most important in the northern states, the light will not be shut out as much by snow during the winter.

It is well to remember when planning large shops having more than two floors that high structures involve the use of power elevators, so the cars can be taken from one floor to the other, with increased overhead expense as it augments the cost of handling cars, either in repair work or storage for which no charge can be made the patron.

Lighting Methods.—The lighting problem can be viewed from two aspects: that of general illumination and the equally important one of individual lighting. For the former, powerful, though well diffused lights are wanted, these being placed high enough so they will be out of the way and yet give as much as possible the general effect of daylight. The amount of illumination needed varies with the different departments and the class of work carried on therein, but in making determinations it is always best to err on the excess side than to attempt to economize at the expense of the eyes of the workman. This is poor economy because it reacts directly upon the quality of the work turned out by the shop. In he car assembling or overhauling department, the general illumination should approximate about 120 candle power to every 200 quare feet, while in a regular shop or room where the general ighting means is supplemented by individual lamps at vises and rop lights to carry to the cars themselves, the allowance of 100 andle power of general illumination to 300 square feet floor area ill be found ample. Machine shop lighting should always be on very liberal scale and should *not only* include good general illu-

mination but individual lighting as well. The general practi in most shops is to use small units and plenty of them. Thirt two to sixty-four candle power lamps or other equivalent radiat are suspended over each machine tool where great accuracy work is not essential, these including such appliances as shaper planers, emery wheels, arbor presses, drilling machines, etc. O lathes, milling machines or grinders, where accurate cuts must taken, the individual lamps should be supplemented by arc ligh or powerful Tungsten lamp clusters, supported from the ceili and well shaded to reflect the light where it is needed. One cand power per square foot floor area in addition to the individu lights, which should be at least 50 candle power over each to designed for accurate work should be allowed in the machine sho

Where electric current is available the most suitable lamp fro the viewpoint of steadiness, quality, and intensity of light is t incandescent filament lamp using the Tungsten alloy illuminati element. The flaming arc is an economical light, but it is far fro being steady and its color is such that it is hard to discover fin lines or colors having a bluish tinge. The fluctuation in an ar light and even the clicking of the regulating mechanism may b come very annoying when engaged in fine work. Many garage an repair shop proprietors in small towns where there is no centr lighting plant find it desirable and economical to generate thei own current by any one of the many small individual lightin units sold for this purpose using a gas or gasoline engine as powe The electric current reduces the fire risk and as it is the mo convenient form of energy for generating power to operate ma chine tools, the installation of individual lighting plants is justifie by the many advantages accruing from the use of electric curren

Where electricity is not available it is rarely possible to fin either coal or water gas such as generated by a public service co poration. In many small, isolated communities it may be nece sary to use acetylene gas generated on the premises. Some favo kerosene or gasoline vapor lamps in which incandescent mantle are employed. One popular lamp in the rural sections which burn oil under air pressure producing a Bunsen flame capable of hea ing the usual incandescent thorium mantle is called the "Washin

n" lamp and is a very economical method of lighting. It is apparent that any system of illumination that involves the use of a naked flame introduces an item of fire risk that is very undesirable in a building where the fumes of gasoline are present.

Electricity is not only the safest method of lighting but the tungsten lamp is the nearest to sunlight of the artificial radiants. Where electricity is available it will be poor economy to use other means of lighting, except for general illumination as by groups of incandescent mantle gas lamps. For individual lighting the electric lamp is the most suitable because it is safe, compact, clean, does not give out much heat, is portable and can be used in any position. There is no other means of artificial lighting that permits one to obtain all of these desirable requirements in combination. Considering the relative cost of the various methods of lighting, the following table, based on the cost per 100 normal candle hours, will prove useful:

	Cents
Washington light	0.238
Flaming electric arc	0.381
Mercury vapor lamp	0.595
Incandescent gas light	0.595
Incandescent petroleum light	0.714
Direct current electric arc	0.942
Osram, zircon and tungsten lamp	1.190
Kerosene burner	1.666

The writer has frequently noticed the use of poor droplights in garages which are not only undesirable because of the physical discomfort entailed by the action of the electric current upon the human system, but also because of the liability of fire. The wire and sockets of these lamps are subjected to very severe treatment and they soon cause trouble where a cheap equipment has been provided, because the insulation of the wire deteriorates and will cause a short circuit whenever it comes in contact with the metal part of the frame or of the various parts of the human system which will provide a path to the ground for the current. Where a current of 110 volts is used, there is no danger of severe or permanent injuries because of contact with such a "live wire," but the sensation *is decidedly unpleasant, to say* the least. Cases

been observed by the writer where a fire has been caused because of such defective insulation of the wire. One case in particular has been distinctly impressed on his mind because he was in a pit beneath a car at the time of the fire. A helper was washing the mechanism with gasoline, preparatory to an overhauling, and plenty of vapor filled the air. A partly bare spot on one of the wires became crossed with the frame work of the car and the brilliant spark resulting ignited the gasoline immediately. The car and pit were in flames and had it not been for the presence of mind of another mechanic with a chemical extinguisher in dealing with the blaze before it assumed dangerous proportions, the result might have been more serious.

In figuring on a droplight equipment, the best material should be obtained. It is a "penny wise, pound foolish" policy to use materials for which the only recommendation is cheapness. The wire should be provided with a very heavy insulation, and need not be very flexible. Beware of lamp cord, as it is of no value for use under severe conditions. The best and heaviest sockets should be used. The writer would advise the use of some that had either a very heavy porcelain or hard rubber insulation around them. Then comes the choice of proper cages or shields and handles. There are cages now marketed that are of heavy construction, the wire of which they are composed being nearly an eighth of an inch in diameter. These will prove to be the cheapest in the end. In assembling, it will be found best to wind plenty of electrical tape around the wires for the entire length of the drop. This not only serves as an additional insulator, but takes much of the wear that would otherwise come upon the insulation of the wire proper, and it may be easily renewed when it shows signs of wear. It will be found well to solder all the connections at the socket and rosette, as there is nothing more disconcerting, when a difficult or tedious job of fitting or adjusting is being performed, than to have a "winking" light to work with, which is liable to fail at the time it is needed most.

Heating and Ventilation.—It is very important that the work rooms should be kept at comfortable temperature during cold weather. About 75 degrees Fahrenheit is usually considered correct

gh it may be lower than this if the men are engaged in active r. In the machine shop where men must stand quiet much of time, the temperature should be higher than in the erecting m, where they are constantly moving around and handling ts, this tending to keep the blood in circulation. It is a mis- en idea on the part of some shop managers that the men must half frozen so they will exert themselves more than if conditions re more favorable to comfort.

This is true if the temperature is much too high, but there is le danger of this happening in a large shop having considerable tal to absorb heat, and where the doors are opened to admit s many times each day. A man cannot work with any degree accuracy if his fingers are numb. When shops are cold, the atives compensate for this by wearing heavier extra clothing t hampers their movements appreciably. What is gained in l is lost in labor, to say nothing of the effect unfavorable con- tions have on the dispositions of the workers.

Of the methods of heating in vogue, the writer unhesitatingly mmends steam or hot water, in connection with judiciously ced radiators and pipes. The amount of radiator surface needed uld be computed very accurately, and can only be determined y taking into account the character of the walls, number of win- ws, cubical contents of the rooms to be heated, the facilities for tilation, the number and size of doorways and many other ditions best considered by a competent heating and ventilating gineer. The steam or hot water boiler has the advantage of nishing warm water at all times for washing purposes, and as radiators may be shut off if too warm, the temperature can regulated to suit requirements and to secure economical and cient heating from the fuel burned.

The problem of ventilation is one that is of importance, though character depends upon the type and construction of the build- gs used. Repair shops are usually of large size, and have large ce in proportion to the number of workmen employed. In ny cases of ground floor shops, this ratio is so large that no cial provision need be made, the air being changed often enough nswer all practical needs, as the main entrance is opened ar

closed. With a number of upper floors, conditions are differ and in such cases every endeavor should be made to renew least one-tenth of the total contents every hour. In paint sho smith, and testing or adjusting rooms where noxious fumes m be present, and in small rooms where the number of workmen greatly in excess of the air space available, no less than half contents should be renewed hourly. The suggestions for buildi heating, lighting and ventilation apply to all shops.

Building Arrangement.—As an example of the amount of sp allowed in a building devoted to both a garage and repair busin

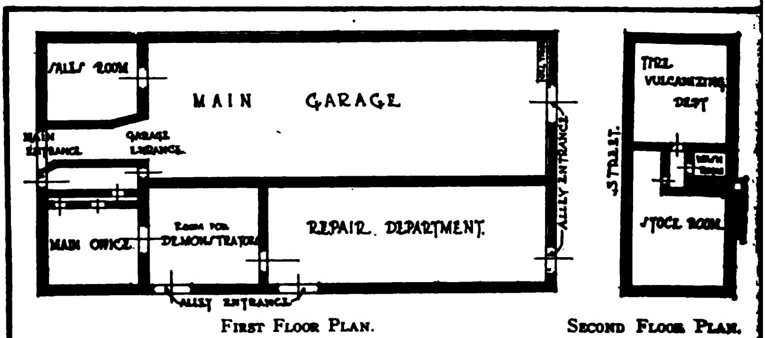
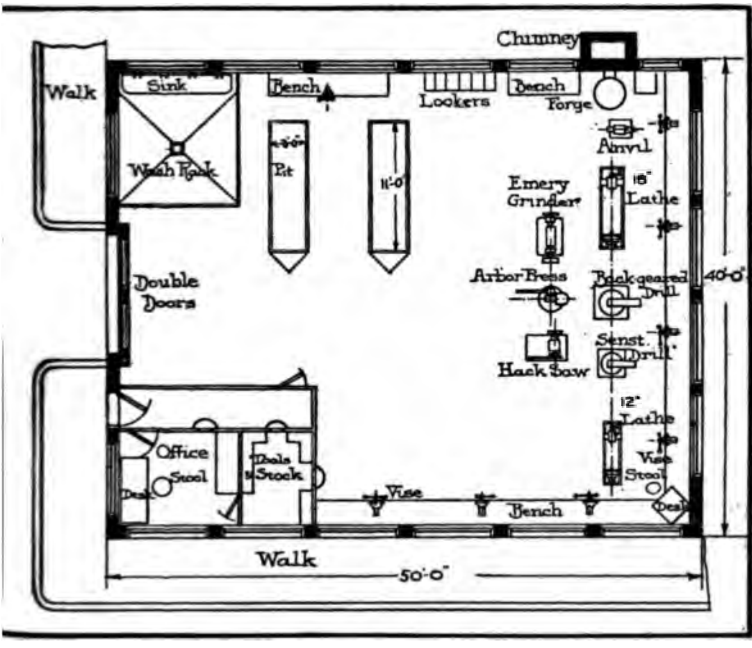


Fig. 1.—Floor Plans of Garage and Repair Shop.

the floor plans of a garage located in a city of forty thousand habitants is presented at Fig. 1. This building has a frontage 74 feet and is 150 feet deep. The front faces a main street and occupied by a sales room 30 feet square in one corner, and a ma office of the same size in the other corner. The sales room h an attractive show window across the entire front, and the oth departments are also liberally provided with windows. One si of the plant faces an alley extending the entire distance, and the is also an alley to the rear. This offers the important advanta of providing a situation on what is practically three well pav streets. The alley to the north is practically exclusive and affor the company a chance to store many cars during the day and *the same time* leaves plenty of room for the vehicles to mo

ound. The plant has five entrances, the main entrance at the ont, which is 14 feet wide, two to the repair department, one at e rear to the main garage and one in the room set apart for the monstrating car. All entrances measure 14 feet across and are aply high to permit the entrance of the largest motor truck. e building is of brick and concrete construction and is two stories



ig. 2—Floor Plan of Small Repair Shop, Showing Location of Pit and Machinery.

height at the front. The second floor front is occupied by the e repair department and the stock room. Skylights over the air department and the garage proper furnish plenty of light m above.

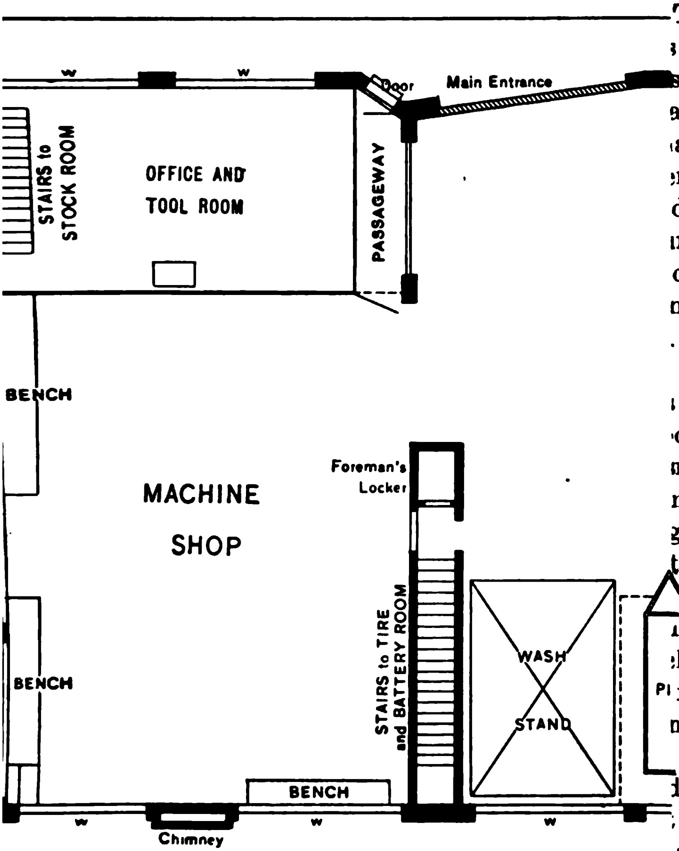
The floor space on the main floor, back of the office and sales m is therefore divided into three sections. The repair depart- nt is 30 feet wide by 120 feet long and is situated to the rear the office. The *garage proper is to* the rear of the show room

and is 44 feet wide and 120 feet long. The repair departmen sufficiently large to employ 18 men. The building is heated steam which is furnished by a heating plant in the basement derneath the main office.

The floor plan at Fig. 2 is that of a small building devo exclusively to repair work and is suitable as a design for a sh to be placed at the side or rear of a garage. This building n only offers ample room to work on seven large cars but also pr vides for a complete machine tool equipment and ample space f office and stock room furniture. There is but one entrance, th being located at the front of the plant. The dimensions of t building and the arrangement of the various departments are clearly shown that further comment is unnecessary. Floor pla are also given at Figs. 3 and 4 for a medium size service statio while a large departmentized repair shop is shown at Fig. 5. medium size repair shop having a commendable arrangement machinery and still leaving ample space for working on a go number of cars is shown at Fig. 6. In many large cities it necessary to use buildings having more than one story on accou of the value of land in business or manufacturing sections

A typical arrangement of a converted factory building th has worked out fairly well for a service station is shown at Fig. This is operated exclusively as a repair shop and has comple facilities. The building is of brick and while not as well adapt for motor car repairing as the specially planned structure at Fi 6 is, it has been remodelled to good advantage. The building 165 feet long and 36 feet wide inside the walls. Considering th the building is an old one built before the days when the provisi of ample light was considered one of the essentials, it is fairly w lighted during the day as the walls are pierced with many sm windows. At night a large number of Tungsten lamp groups high candle power furnish the general illumination. Both floo are divided into three rooms, the largest 104 feet long being used an assembling and storage room on both floors. On the lower flo there is an intermediate room 28 feet long into which the elevat leads that is also used for assembling and overhauling purpos The remaining small room on the ground floor which is 25 fe

, the
s are
This
s not
s ac-
akes,
an a
nter
ding
nter
door
n on
. the



the
oses,
mall
mith
gives
ts in
ver-
ling
hine
it is
ment

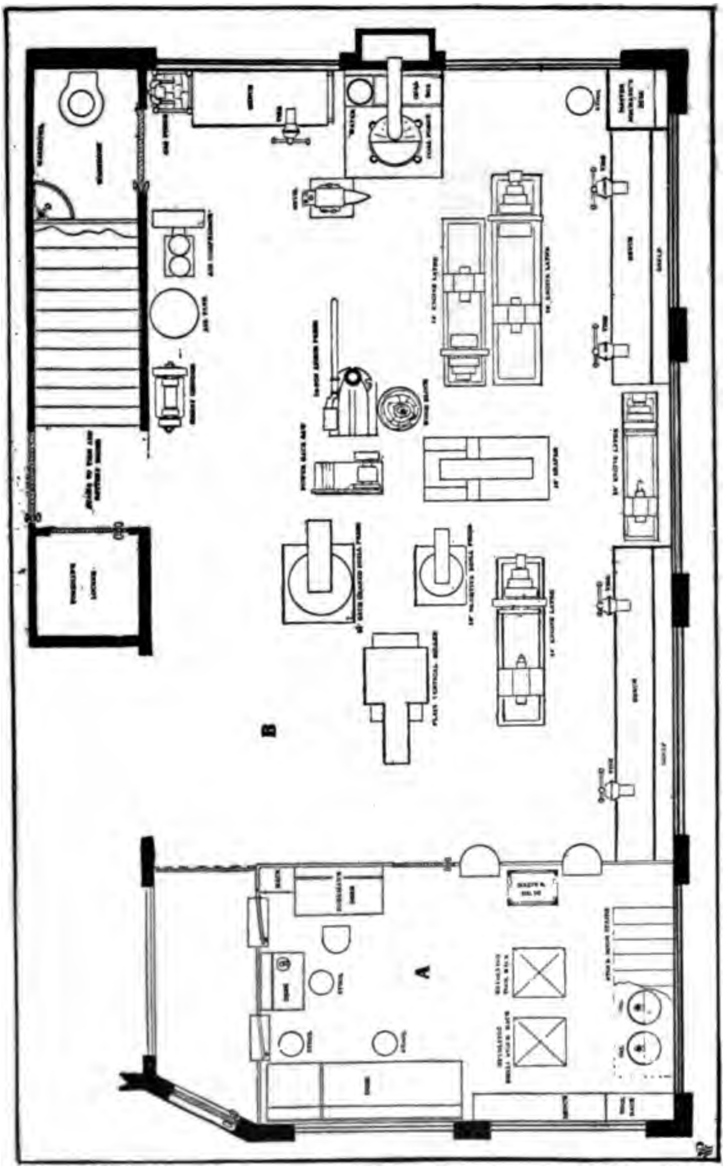
l ex-
the
lay-
rays
nce
ding
de-
l re-
nces,
while
shop.

and i
suffici
steam
derne
Th
exclu
to be
only
vides
office
being
buildi
clearl
are al
while
mediu
machi
numb
necess
of th
A
has w
This
facili
for m
6 is,
165 f
the bu
of an
light
wind
high
are d
an ass
there
leads
The

g is divided into three parts, one being used for an office, the ıers for stock and tool rooms, respectively. Nine large pits are ɔvided on this floor and there is also ample bench room. This ɔund floor assembly department is devoted to work that does not volve taking down a car to any extent such as fitting various ac-sories, tuning or adjusting engines, repairing clutches, brakes, les, etc., and other work that will not lay up a car for more than a w days. There is a large door at one end to permit cars to enter rectly from the street and a smaller entrance at the other leading rectly into the passage way in front of the stock room counter rer which the patrons are served. There is also a large door pening into the rear of the elevator, permitting cars to run on ae elevator when this is in its lowest position, either from the hop interior or from the street.

The upper floor is divided in much the same manner as the ower one, the largest room being used for overhauling purposes, he 36 x 28 feet room is used as a machine shop, while the small room over the office and stock room is used as a forge and tinsmith shop. A large skylight in the roof of the blacksmith shop gives much needed light on the anvil and bench. There are no pits in this floor but, as is the case with the one below, there is an over-head track extending the full length of the room for travelling chain falls attached to the ceiling. The equipment of the machine shop is very complete and enough tools are provided so that it is possible to duplicate any part of any automobile. The equipment shown at Fig. 6 is also very complete.

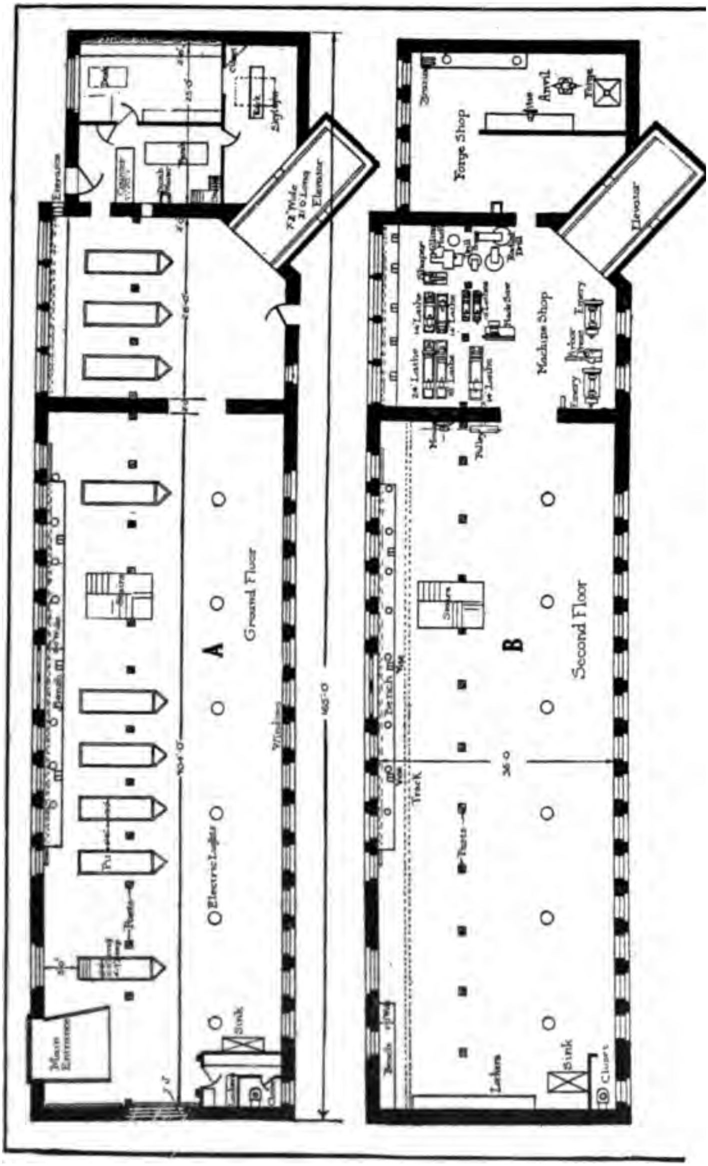
In the building outlined at Fig. 6 which has been designed exclusively for automobile repair work it will be noticed that the saw tooth roof and the many windows make for maximum day-light illumination. The windows of the saw tooth should always face toward the north to get the best light and prevent annoyance due to the sun shining directly in during the day. The building may be of either brick or concrete and while the arrangement depicted is very good, the plan may be varied to suit individual requirements. It will be observed that there are two main entrances, one a small door, leading directly into the machine shop, while there is a large main door by which the cars enter the repair shop



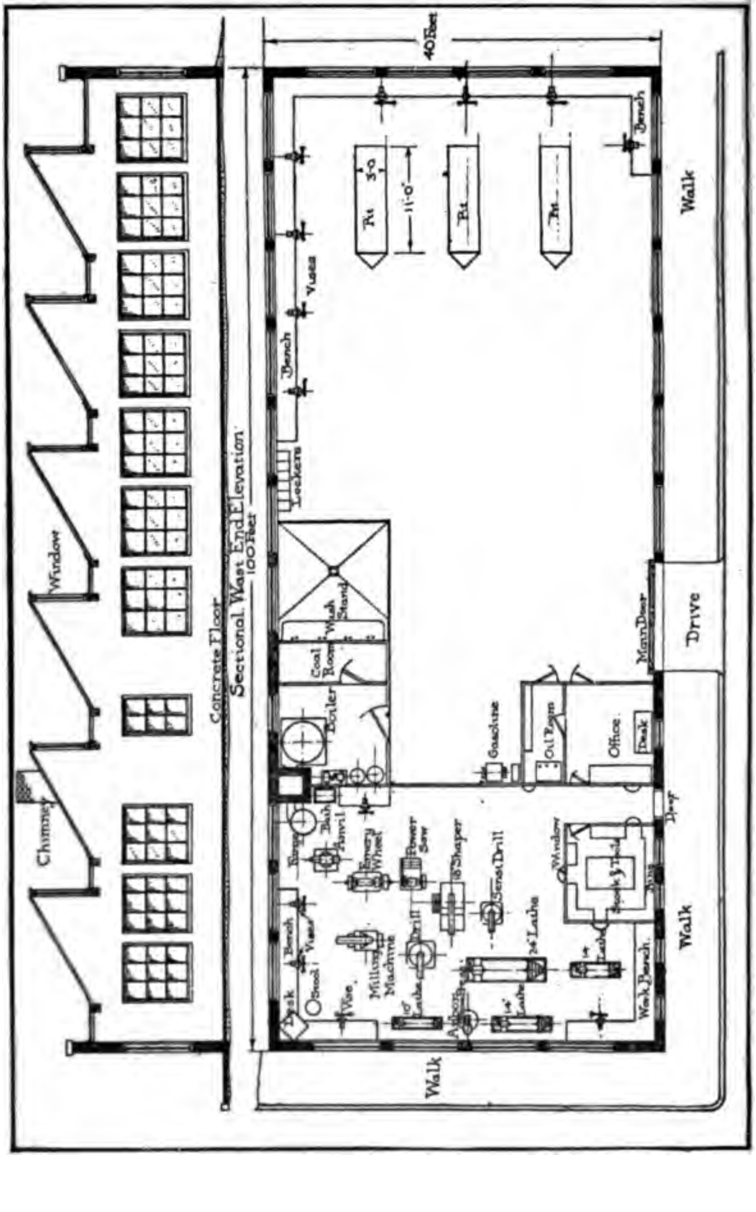
B
A

will be noted that the office is placed in such a way that all that on in either the machine shop or the assembling department be seen by the executive or manager. The location of the k and tool room in the machine shop is logical, as it is most venient for the men who have frequent need of special tools. men on the assembling floor usually have their own outfits, eas the machinists are continually using special drills, taps, and cutters that the company must furnish. A person cannot r the machine shop without first passing the clerk in either office or the stock room, as wickets in the walls of these rooms ning the passageway open directly into the narrow hall provid access to the machine shop. A pair of large double doors rates the machine shop from the assemblying room as it is n necessary to move in bulky portions of automobiles for attion. In the building shown the boiler room is partitioned off the assembly room and it is not intended to have any baset. If a cellar is provided, however, the heating boiler may be ed therein and be out of the way. The equipment of the ious departments which can be applied to any of the repair s shown will now be considered in connection with the logical ngement of the repair shop department.

Arrangement of Departments.—In arranging the departments layout should be for greatest efficiency and convenience. This lies to the repair shop as much as to the manufacturing plant, l intelligent study will often result in changes which will matally increase efficiency. Many shops are not profitable because lack of organization and lack of system, while others are handipped because of poor general arrangement. The owner or manar of a small shop may consider that the installation of a methodil system for record of the cost and progress of the work involves expense that is unnecessary, and many shops are conducted by hit or miss principle when simple accounting methods and organition of force would make them much more profitable. Too much tem, however, is as bad as not enough, so a happy medium been the two extremes should be adopted. There should be some tinct scheme of organization in every shop of any size, espelly in those which employ 18 or 20 men, and this can be advan-


Ground Floor
A
Main Entrance
Electric Lights
Sink
Window
Entrance
Elevator
Forge Shop
Anvil
Forge
Machine Shop
Stairs
Bench
Track
Second Floor
B
Lockers
Sink
Closet

ıly followed where only five or six are employed, to the ex- ! properly apportioning the responsibility and authority.
: plan shown at Fig. 3, A, is a one-story structure with a ry frontage, having a capacity for 30 cars. The building ıt 120 feet long and 40 feet wide, divided into departments venience. The ground floor contains four departments. The ıpartment is about 40 by 20 feet, which is again divided, l room and office being 10 feet wide by 16 feet long, the e room about 30 feet wide and 20 feet long. The rear of p is partly divided by a partition extending about 15 feet he right wall, and about 20 feet from the rear wall. The ack corner is partitioned by a brick wall into a room about wide by 10 feet deep, this serving as the boiler room for the ; plant. The space between the front and back portions, 0 feet, is used for general repairing, for taking cars apart ring cars ready for delivery.
ground floor has been divided into four parts—the tool nd office, the machine shop, the assembling bay and the lling room. The second story is about 25 feet deep and as at Fig. 3, B, is divided into three parts, a stock room with frontage, a battery room 10 feet wide and a tire repair he same size as the stock room. The entrance for cars is ide of the building, and the door opens into the large room machines can be run directly back into the overhauling de- nt, or ranged along the walls of the assembling room. A assage leads from the small door at the side directly to the e shop, though all entering must first pass the office before admittance to the other departments. The plan shown applied only where the building is located at a corner, or here is a short street or alley at either side. This form of ction permits one to take advantage of the whole front of p, and no space is sacrificed, as would be the result if the ıtrance and passage were located at the front of the building. office and tool room are partitioned from the machine shop thing and wire netting or grillwork, the wood of the par- eing about four feet in height, all space above to the ceiling lled by wide mesh net. *Thus the tool room* is effectually



Chimney
Window
Concrete Floor
Sectional West End Elevation
100 Feet
40 Feet
Bench
Vises
Pit
3-0
11-0"
Lockers
Wash Stand
Coal Room
Boiler
Gasoline
Oil Room
Office
Desk
Main Door
Drive
Walk
Engine
Bath
Anvil
Emery Wheel
Power Saw
15" Shaper
Sensi. Drill
24" Lathe
Stock & Tool Room
Window
Door
Milling Machine
Drill
10" Lathe
14" Lathe
Arbors
Vise
Stool
Work Bench

rated from the machine room, and yet all that goes on in either room can be seen by the superintendent when in one room or the other. Two partially open partitions extend the width of the tool room, the one separating it from the passageway, the other from the machine shop. In each partition is placed two windows, fitted by swinging screens. Along a portion of the side wall and under the stairs are tool racks, while many of the smaller and often-called-for tools, such as drills, taps, dies, reamers, etc., are carried on pyramidical revolving racks. These racks can also be used to advantage for nuts, bolts, machine screws, splitpins and other small stock often demanded.

The bookkeeper and clerk share a common desk ranged along the side wall, while the stenographer has a typewriter desk between the two windows communicating with the passageway from the street. This makes it possible for the stenographer to wait upon customers applying at either window. The one nearest the door permits a visitor to talk with either the clerk or bookkeeper, while that at the other side of the desk allows the caller to talk to the superintendent or manager, whose desk is conveniently placed so that he can look into the shop, keep his eye on the tools and stock, talk with either bookkeeper or clerk, or dictate a letter to the stenographer without leaving his chair. As no modern business is complete without telephone service, a single desk instrument with extension cord is placed on the stenographer's desk, and can be used by the superintendent, the bookkeeper or the clerk without leaving their work.

How Raw and Finished Stock Is Stored.—The arrangement and type of the racks can only be determined by the nature of the raw and finished material carried in stock. The stock room is directly over the office and tool room and a dumb waiter or small elevator as well as a stairway connects both floors. At Fig. 7, A, is shown a type of rack that can be used to advantage in storing small parts, this having lower bins of larger size for bulkier articles. At B is shown a combination rack for stock, both finished and rough, having a series of pigeonholes for tubing, bar steel and iron, etc., while the type at C permits one to store sheet stock as well as other and less bulky articles. A practical form of rack

for bar iron and steel, tubing, etc., is at D, this being a se cast iron members joined by through bars, so coupled as to braces. A most practical form of rack for the repair shop room would combine the forms shown at A, B and C, the ba rods being put in from one end, the sheet metal, fibre, etc. placed in the compartments at the other.

There is no need of mentioning the ways in which nuts machine and wood screws can be best handled. Any stock : experience would place these in revolving pyramidical ra

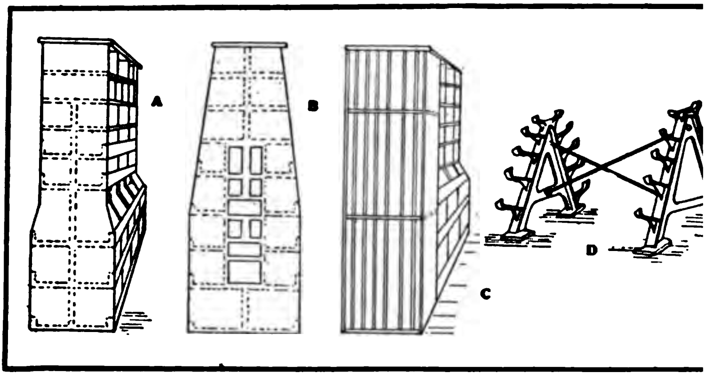


Fig. 7.—Bins and Racks for Storing Raw Material Used in Auto: Repair Work.

small cabinets where they can be easily reached, which per marking for ready identification. Wire, rubber hose, flexib per and brass tubing, etc., need only be coiled and placed c venient hooks; pipe fittings, gaskets, and small parts sho strung on wires and suspended from nails; sheet packings, matting, etc., ought to be left on the roll, and mounted on so they can be easily unrolled.

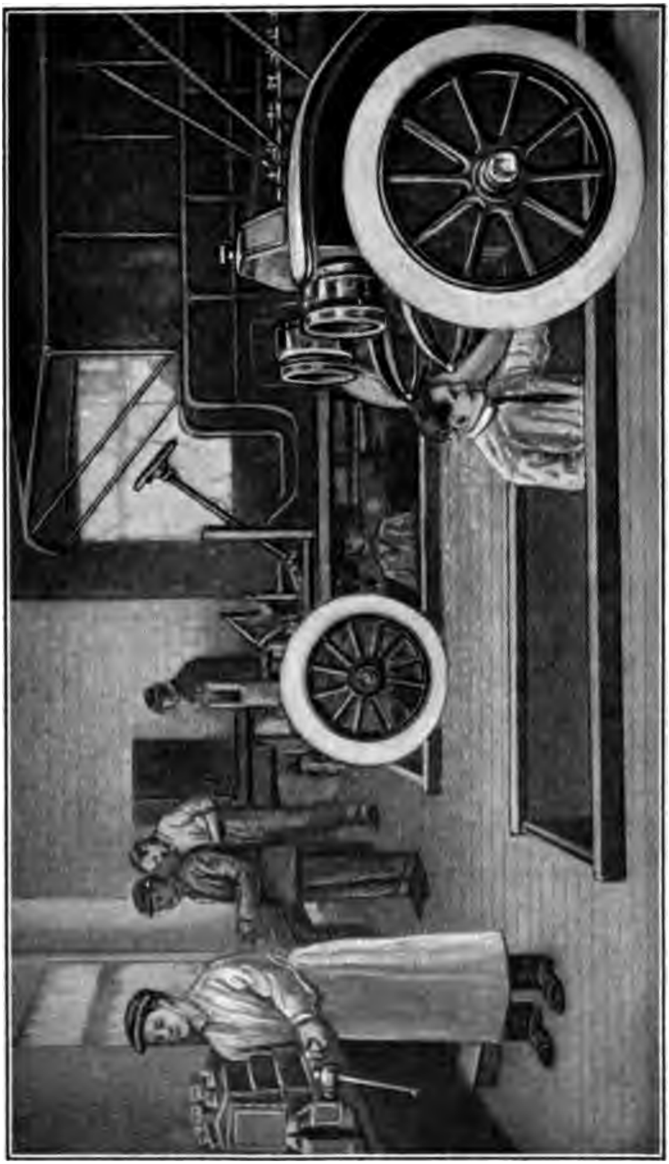
A desk should be provided for the stock man convenient stairs and dumb waiter or elevator. All smaller articles sent from one floor to the other by the elevator. The oil stored in the regulation pump-fitted tanks, while the grea be kept in the original package if bought in bulk. These

red in the tool room, as well as other stock that may be fre-
ly called for. A good place for both oil and grease is under
airs leading from the lower to the upper floor. A convenient
ge place for waste is the interior of the revolving rack on
the smaller tools are placed.

all well regulated shops there is a system of tool checking,
the workmen being provided with small brass discs punched
a number by which the employee is known, one of these being
ndered to the tool boy for every piece taken from the tool
, and which is returned to the workman if the shop tool is
ndered in good condition. All broken tools should be im-
ately reported to the master mechanic or superintendent. No
ation should be made from the established rule, and no tool
ld go out of the tool room unless properly checked.

Every stockroom should have two weighing machines, an ordi-
spring balance registering to 20 or 30 pounds and a platform
so that all raw stock bought or sold by weight can be weighed
re acceptance or delivery, and it will be found a distinct con-
ence to have a certain portion of shelf, table or wall measured
n feet and inches by which the length of wire, packing, etc.,
be quickly determined without frequent search for a mislaid
rule or yard stick. A card index and good stock numbering
m will facilitate finding the location and price of any raw or
hed material, and this can be best worked out as the actual
litions demand. If the repair shop management operates a
ge and agency in connection, spare parts for the machines
ld be kept entirely separate, and in different racks or bins,
distinct from the raw material.

Lockers and Washroom.—The arrangement of lockers, wash-
and toilet facilities are shown by the floor plan. The wash-
d may be a long cast iron sink, or the more sanitary enamelled
vidual steel washbowl series placed in the market recently.
nty places are enough, but all should have separate hot and
l water faucets, though they can discharge into a common pipe.
location near the heater simplifies the plumbing and provides
water without delay or waste. The lockers should be about
nches square and six feet in height, having a shelf about a foot



n the top, and provided with hooks for clothes. The metal llwork construction is to be preferred to the less sanitary wooden ncturcs. All doors should be fitted with locks, and the work-n charged a nominal sum for the use of the key, to be forfeited the key be lost. Two series of 10, placed back to back, are own, another series for the overflow being ranged along the op-site side wall, or any other convenient place. The workmen gularly employed should be given the series nearest the sink, hile the extra help may be assigned those available.

Assembling and Overhauling Departments.—Referring to the or plan shown at Fig. 3, A, it will be seen the remainder of the ilding is divided into two parts, the larger room for light re-airing, assembling and taking cars apart, and for storing cars waiting attention or delivery, while the back room is used for verhauling. There is no close distinction drawn between the de-artments, however, and the same general class of work is carried n in either portion. The larger room has a cement floor, but over his is laid a wooden floor which runs along the walls, extending bout 10 feet from either side. This room is provided with two its as shown, and directly across the floor from the entrance is cated the washstand, so that a car can be run in and cleaned ithout interfering with operations in the shop. The object of e wood floors or platforms is to keep the workmen from direct ntact with the cement floor, especially in cold weather. The de on which the door is placed is used for storage, while at the pposite side is performed the work upon cars. To facilitate work d save time several short work benches, each provided with a se, are ranged along the walls, so that workmen do not have to to the front or back of the shop if bench work is necessary.

An overhead track and travelling chain and tackle make pos-le the lifting of the front or back end of a car, or carrying an gine, gearset or heavy object from the machine room clear to back of the shop, or vice versa, without trouble. A useful ad-ct is the travelling crane, shown at Fig. 18 in use, mounted on els, which can be taken from one part of the shop to another, brought to the work instead of the work being taken to it, as ecessary with a fixed overhead *track*.

Construction of Shop Bench.—The machine or repair s bench must be convenient to the machines, and ample space sho be allowed for a person to pass between the workmen at be and machine. Four good swivel vises and two surface plates well as a couple of small bench anvils will serve for a small sl About five or six feet of bench room should be allowed betw each vise. The bench will be about two feet wide, and 34 or inches high. The legs can be made of iron pipe or castings, o two by four inch scantling, while two inch planking across the will form a backing for another covering of seven-eighths i hardwood floor strips closely fitted together. The average chine shop bench of rough plank with gaping cracks along the cannot be too strongly condemned, as not only is it difficult work on the irregular surface, especially in laying out fine w but many small parts will be lost by falling through the openi in the bench top of the floor. A strong shelf should be placed the wall about two feet above the bench for tools, stock, etc., w not in use, and a heavy shelf under the bench, about 18 inches f the floor, can be used to hold the odds and ends accumulated i machine shop.

A very practical shop work bench may be constructed by u cast iron bench legs that may be obtained upon the open ma as a foundation to which the timber and planking of which bench is composed is attached. The approximate form of o these legs is shown at 1, Fig. 9, which also outlines the amou space recommended between the bench and wall for heat to and to check window draft. This space, which should not be than three inches wide will also allow water from the sprin system to reach any fire under the bench. The end view s the usual method of building and the approximate size of planking of which the bench is composed. The office of the iron leg is to make possible a stiff bench without dependi the walls for support, as is the case with the usual wooden bench.

It would be apparent that this construction lends itself well to various factory conditions as the bench is a unit stru when built up that may be changed from place to place wit

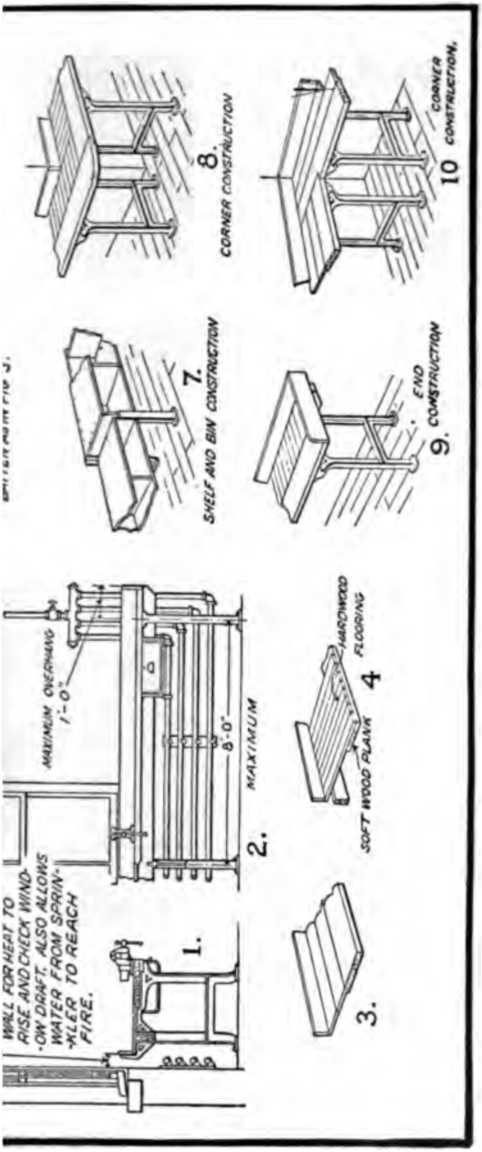


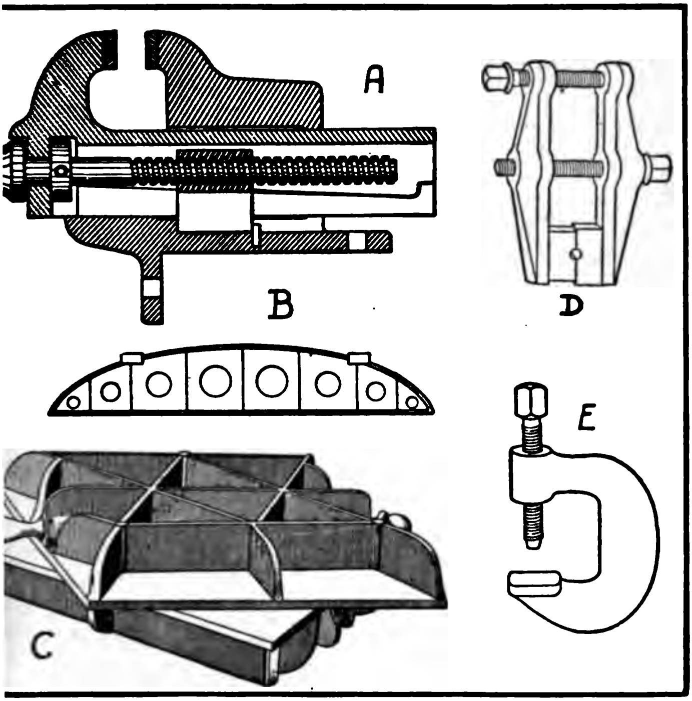
Fig. 9.—Methods of Constructing Shop Benches, Using Standard Cast Iron Bench Legs.

damage. The brace between the legs is just at the right he from the floor and is so built that it forms a basis for underne shelf and bin construction, if desired. These bench legs are spa not more than eight feet apart and the benches should hav maximum overhang of not more than one foot as shown at 2, 1 9. The views at 3 and 4 show the accepted method of arrang the planking. The system outlined at 4 in which hardw matched flooring is used is a very satisfactory one, as there is opportunity for loss of small parts through gaping cracks, s as exist in the usual hastily constructed shop benches. The met of using the bench legs for support of bins or drawers is cle shown at 7, while two methods of corner construction are sh at 8 and 10. The former shows the usual practice in building bench around a projecting corner while the latter demonstr clearly the system used in filling a corner. The usual end c struction is outlined at 9.

Bench Furniture.—The most important item of bench fu ture is the machinist's vise outlined in section at Fig. 10, A. Th are obtained in a variety of types adapted for the various mech cal trades. The vise for the automobile repair shop should h swivel jaws and should be capable of being set at various positi relative to the operator by means of a swivel base. The fo shown in section is the simplest type and may be used for furni ing most of the bench space. Two or three of the cheaper simp forms of vise may be used to each combination swiveling vise, most of the work will be of a nature to which the simpler vis adapted. The various forms of bench vises are clearly shown Fig. 11. The Massey is a combined form adapted for pipe straight work. The serrated angular jaw plates are set beneath parallel jaws used for straight work. The Prentice device is combination form that may be included with advantage in the equ ment of all shops. It will be observed that the back jaw is moun in such a way that it may be swiveled to assume any desired an when an irregularly shaped piece is to be held by lifting out locking pin A which serves to keep the jaw in the parallel p tion when it is in place. In order to swing the entire vise aro *without loosening the* anchorage plate it is necessary to lift the

keeps the upper and lower parts of the base in a fixed

her form of bench vise that is of value when fitting small
known as a die sinker's vise because of its almost universal
ıechanics of this class. This is carried by a base piece hav-



'ig. 10.—Some Indispensable Items of Bench Equipment.

rge ball formed at the lower end held firmly between a
aws that may be tightly clamped by a hand-locking lever.
ıe apparent the use of a ball and socket joint to hold the
ıles the operator to set his work in any one of a large
ıf positions. By releasing the clamp lever the ball is free
ket and the vise may be set at any desired angle.
'olumbian pattern is the *old stand-by* of blacksmiths and

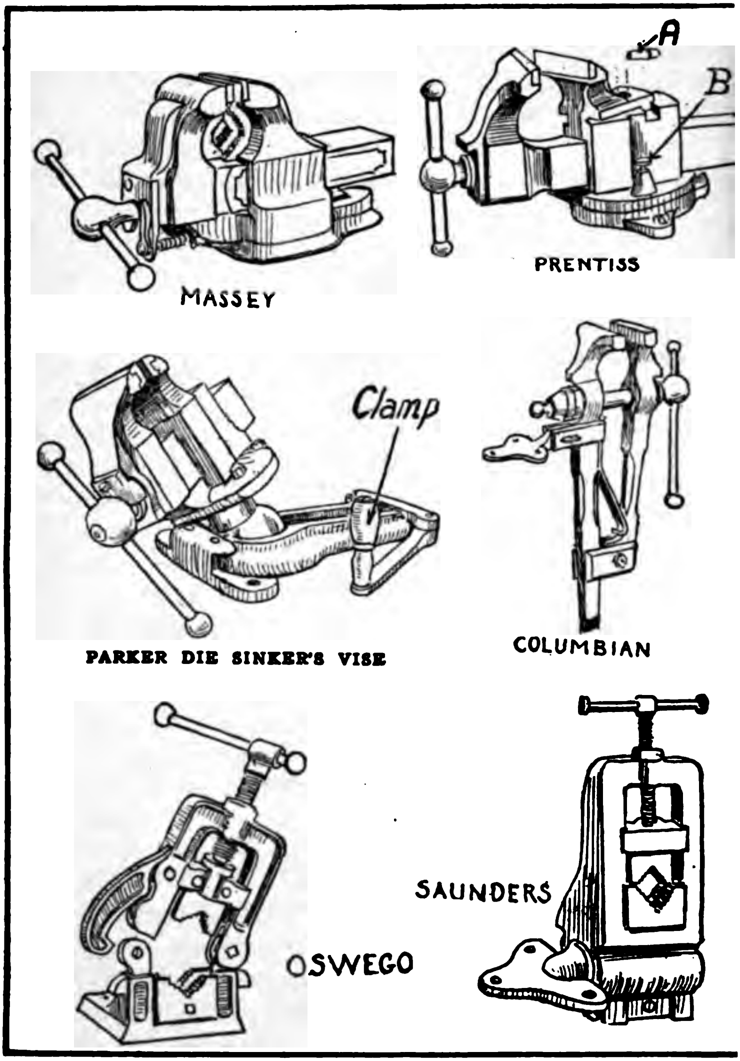


Fig. 11.—Types of Vises Adapted for Use in the Automobile Repair Sl

s, and as it is a form that is subjected to hard usage, g clamp which is bolted to the bench in the customary e-enforced by a heavy ball end supporting foot which : floor. This form of vise is carried out further from han the other types shown, because a blacksmith must g pieces of iron or steel and bend them at various

of the pillar for supporting the vise structure is made because the work is often subjected to heavy blows in s smithing operations. The Columbian is usually in- 'orge equipment and is used at the blacksmith's bench. wego and Saunders are forms of vises used only for ›es and rods. These employ toothed jaws which may be ı the frame to accommodate various sizes of pipe. The e frame is made in such a way that a long piece of pipe ld by opening up the frame and slipping the pipe in 'een the jaws through the opening provided. In the rise it is necessary to put the pipe in end first which :onvenient when long lengths of pipe having fittings on handled. Of those shown, three forms should be in- the equipment of every repair shop, these being the ›sented by the Prentice, Columbian and Oswego.

r item of bench equipment of value is the straight edge Fig. 10, B. This is a very useful tool in the automobile ›, as it is widely used in testing alinement of the various ightness of frame members or tubes and for all pur- re comparison must be made with a perfectly true l straight line. The form shown is made of cast iron ıstruction and with a perforated web in order to obtain strength without too much weight. Another item of ment is the surface plate which is shown at Fig. 10, C. made of cast iron, well ribbed at the back for rigidity the top surface planed accurately. A surface plate is vhat as a straight edge is and is a form of gauge very letermining flatness of surfaces. The bench equipment include a variety of metal hand clamps, two forms of shown at Fig. 10. *The two screw* type having parallel

jaws is shown at D, while a C clamp is outlined at E. Clam are very useful in holding parts together temporarily that are be fastened by some permanent means. They are useful adjun to the bench vise and have the added advantage that they can moved when pieces are to be held against members that it wo be difficult to hold in the vise. For example, in fastening var irons and braces to an automobile frame, the clamps are invalu as a temporary means of keeping the members together while dr ing for the permanent bolts is going on. Many of the rep operations to be described call for the use of clamps as shown.

Assembling Room Furniture.—There are a number of artic of equipment or furniture that are very useful on the assembli floor. That shown at Fig. 12, A, is a bench constructed of hea timbers of such a form that it is well adapted to support auto bile engines when these are removed from the car frame. A ben of this construction is also of value for supporting the vari crank case components when work is being done on them that quires that they should be held level and securely. In the illu tration a portion of a crank case is shown in such a position th work may be done upon the bearings. The simple supporting f ture shown at B is exceptionally useful for holding automob rear axles. It is of approximately T form, being composed of t pieces of planks and three uprights well braced with iron bars a mounted on casters so the load may be moved with but little eff The form of bench used and its actual construction will, of cou depend upon the type of axle that is to be supported. The mem shown is intended for torque tube axles.

Another very useful piece of furniture is a trestle or h such as shown at C which forms a good means of support for of the parts when these are removed from the car chassis. A of these trestles should be included in the garage equipment they can be used together to support a front or rear axle, eng automobile frame and other bulky objects. The form outlined a folding steel construction which occupies but little space wh knocked down. It is strong, light, and fire-proof, all very g features in garage equipment. The workman engaged in fi work is often handicapped by not having some means of keep

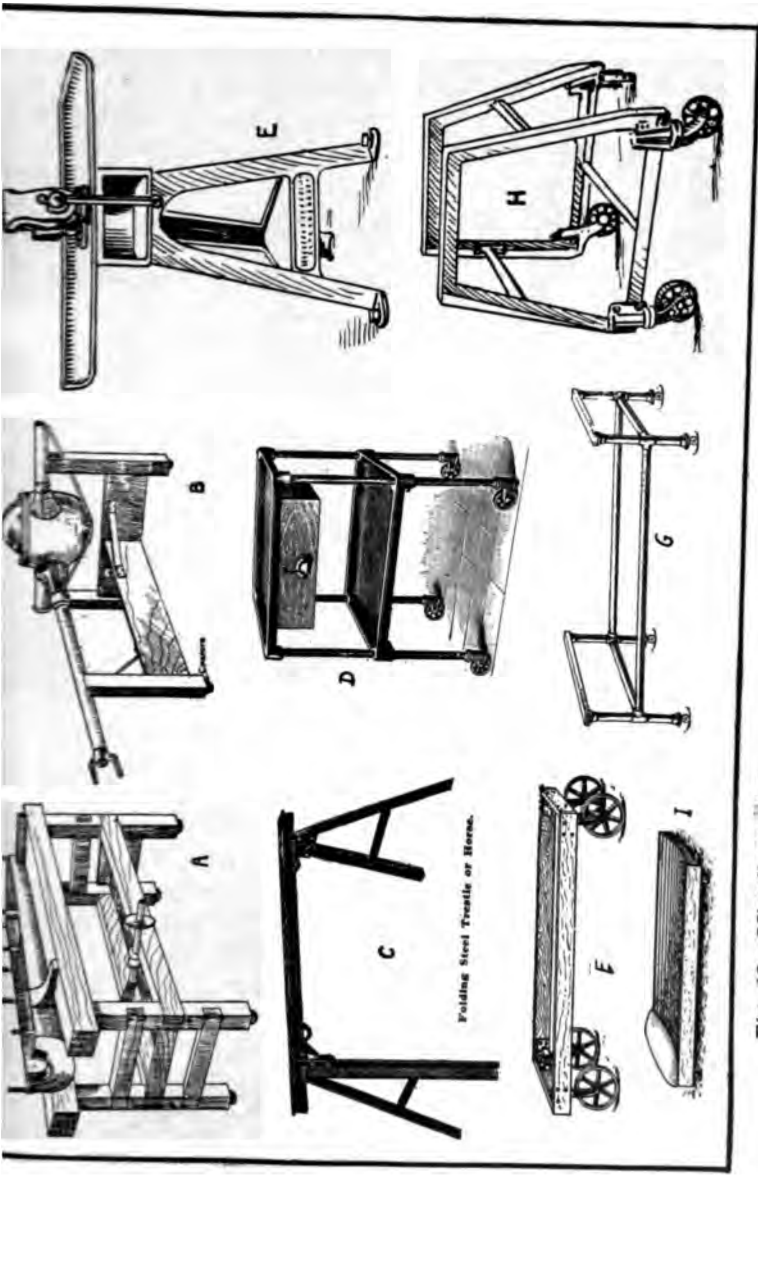


Fig. 12.—Miscellaneous Items of Shop Furniture for Use on the Assembling Floor.

tools and small parts off the floor when working away from bench. The metal table shown at D is very well adapted for individual workman's use, as it is provided with a drawer in wh tools may be locked and also with a substantial metal top shelf on which work may be done. The table is mounted on wh and may be easily moved, even when loaded to capacity. Ano useful adjunct to the assembling department equipment is sh at E. This is a cast iron bench having a vise attached and moun on a tripod which offers a substantial foundation. There is a co partment immediately below the bench top for holding tools an shelf above the floor that may be utilized for the same purp The table shown at D when fitted with a rack at the side and b is also well adapted for use in the forge room, as it will hold of the blacksmith's tools and cannot be set afire by a piece hot iron as a wooden bench is. The addition of the rack make possible to carry the assortment of tongs usually found at forge.

Three forms of wheeled trucks are shown at F, G and H. T at F is a low framework that may be boarded over and used conveying heavy parts from one end of the shop to the other that can be used just as shown for conveying axles, engines gear boxes which are of irregular form and which could not be veniently carried by a platform. The truck shown at G is m of pipe fittings and is used for supporting automobile fra when the springs and axles have been removed. As this is provi with wheels it can be easily moved with its burden as desi The cast iron stand at H was designed especially for hand transmission gear boxes in a service garage where one partic make of car was looked after exclusively. As designed it was suitable for use with the gear box found in this car. By b slightly modified to the extent of having adjustable brace mem joining the two sides it could be used to advantage for a var of purposes. The small wheel truck shown at I is known "creeper" and serves to keep the workmen off the floor w working underneath a car. This is provided with a head at one end and it may be easily moved about without the work using it getting up from his reclining position. These trucks

rovided with a shelf at one side to support tools and
iat these will move whenever the operator does. The
es of furniture outlined will be susceptible to various
t will adapt them to the specific work in hand, and a
of any pretentions will be able to use all of the furni-
to good advantage.

ction and Size of Pits.—The back shop shown at Fig.
ro pits, and the arrangement of the work benches can
t the end of the short bench placed against the boiler
a pipe vise, while at regular intervals along the benches
trong swivel vises. This bench is 30 inches deep, about
iigh, of rough construction, and built very heavy to
. The pits are four and one-half feet deep, three and
t wide and 11 feet long. They are lined with heavy
nd stairs permit the workmen to descend and ascend
rt. Along the side walls of the pits and about two and
t above the bottom, two pieces of two by four scantling
l, these to support a board that may be moved from one
pit to the other, as a seat for a workman. With more
of the motor truck it will be well to install a larger
er pit, as the mechanisms of these vehicles are carried
in the conventional touring car. Such a pit should be
and one-half feet deep, four feet wide and 14 feet long.
of all pits should be sharply defined by a surrounding
ro by four scantling; this being a guard to prevent the
ng into the pit while manœuvering a car about it.

w at Fig. 8 shows the depth of the pit with an operator
pright and also depicts clearly the frame work around
guide the car wheels. The amount of space allowed be-
dge of the pit and the workbench is also depicted. In
it is customary to have a pit cover made in sections so
only one end of a car is to be worked on but a portion
is used, the remainder being covered by one section of
prevent the workmen at the bench from falling into the
ie shops the electric wiring is run to the pit interior and
lug socket so that a drop light or extension cord may
d without the necessity of having a long length of wir

trailing over the floor as is necessary when the connection is m to one of the lamp sockets over the bench.

Turn Tables, Lifting and Moving Appliances.—In many rep shops where the floor area is limited or where the floor spac broken up by a number of posts it is often difficult to move c about even under their own power and it takes considerable n nœuvering to head the car around in the other direction. The id solution of this problem is the turntable in its various forms. ' simplest and cheapest is in the form of a small wheel truck as sho at Fig. 13, having the wheels mounted on a swivel carriage so t

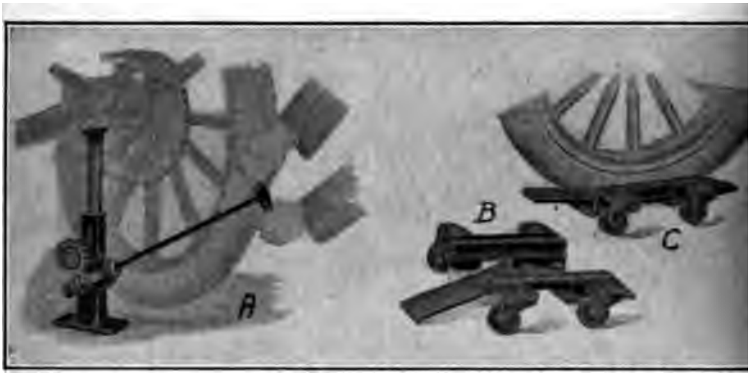


Fig. 13.—Method of Utilizing Simple Substitute for Turntable.

can run in any direction. To use this useful accessory the f step is to jack up the car as shown at A, and then run the tr under the wheels letting the wheels down when the truck is in pl The car may be run onto the trucks under its own power at one while it is necessary to raise the other two wheels in order to the small truck. When four of these are used, one under e wheel, it will be possible to swing the heaviest car around with much exertion.

An objection offered to the large turntable is that a pit is ne sary in order to have these flush with the floor level, and most the structures offered are costly. A very simple arrangement t *will work very* well without requiring alterations to the floor

ı at Fig. 14. This rests directly on the floor and consists of a lar iron track having a number of ribs or spokes radiating to a al hub which serves as a pivotal point for the load carrying ıge. The carriage is made up of two channel iron beams fas- together by a spacer casting, having at its center a suitable ıg to engage the pivot pin. This serves merely to locate the carriage and is not called upon to support any of the weight, ı is carried by a series of wheels resting on the track and ely attached to the side flanges of the channel section beams. e height of the beams from the floor is but two inches, it is

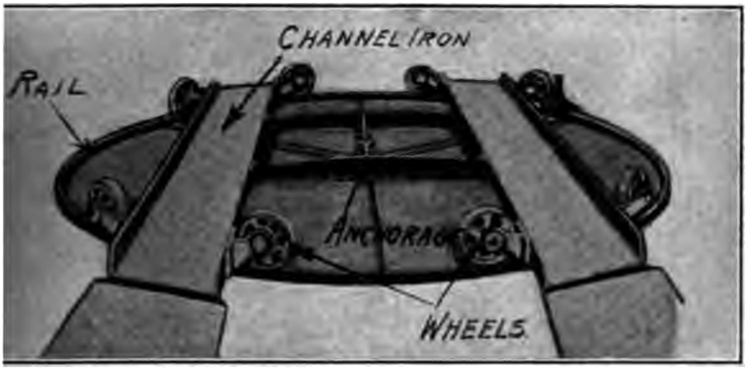
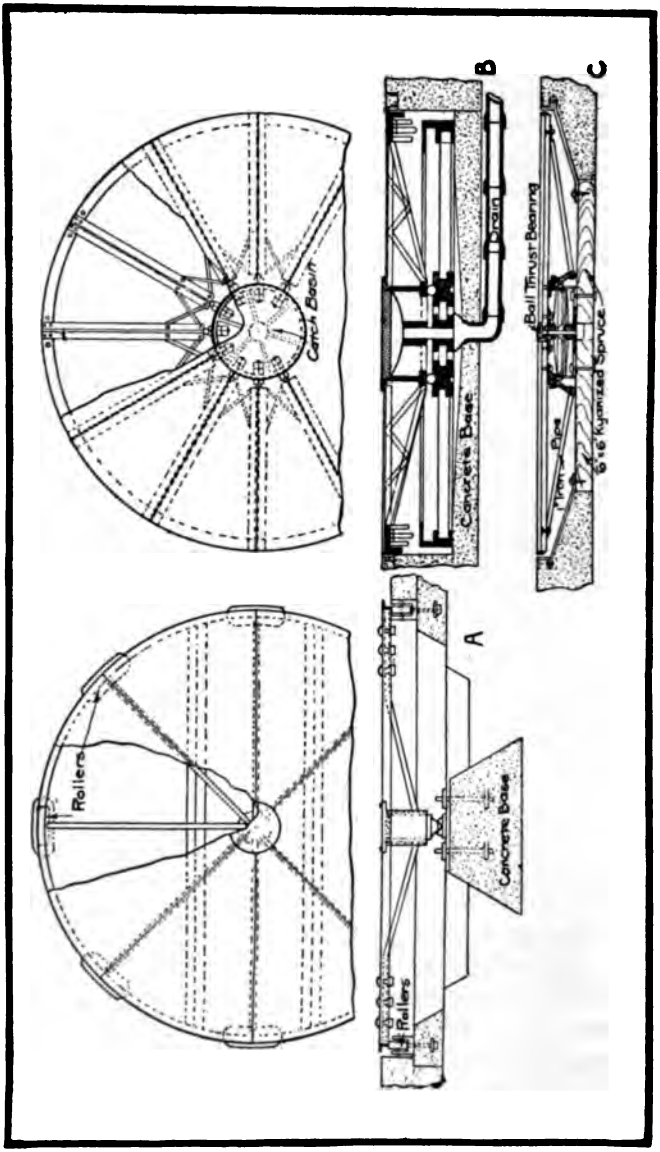


Fig. 14.—Outlining Construction of Pitless Turntable.

ible to use a pair of wedge shape planks as an approach to the table. The side of the channel irons also serves a useful purpose les offering a means of securing the supporting wheels and er frame, inasmuch as they offer a guide so the wheels of the cannot run out of their correct path. These turntables may be red in sizes, capable of handling any weight of car and will ound an effective substitute for the more expensive built-in table.

Two forms of built-in turntable are shown at Fig. 15. It will bserved that with these it is necessary to make a pit in which a ion of the mechanism is concealed. The form shown at A is up of angle irons and steel plates and the load is carried at


Catch Basin
B
Drain
Concrete Base
C
Ball Thrust Bearing
6'x6' Kyanized Spruce
Iron Pipe
Rollers
A
Concrete Base
Rollers

e centre by a pivot or step journal mounted on a substantial ncrete base and at the outer periphery by a series of rollers rried in supporting castings securely anchored to the concrete undation. The form shown at B, carries the weight on a large ll bearing and has an added feature of having a catch basin for ater and other drippings from the car at its centre, so this material ill be conducted to a drain instead of filling the pit as is the sult when no precautions are taken for drawing the liquid off. he design shown in section at C, is a modification of the type ustrated at B.

One of the most useful of the accessories comprising the as- mbling floor equipment is the load-raising and supporting jack, rious forms of which are shown at Fig. 16. The type at A, is ratchet form having a single trip lever which can be set so that e same movement of the actuating bar will either raise or lower e lifting ram as desired. The jack at B, is similar to that at A, cept that the lifting ram is provided with a double head, making possible to use the jack on those low axles where it is difficult to t the jack directly under the member to be raised. The jack at is a double geared arrangement in which the nut serving to raise e lifting screw is turned by bevel gears worked by the customary er. The tire saving jack which is shown at D, is used for keep- g the wheels of cars that are to be stored for some time off the r and thus relieve the tires of the car weight. These jacks have e advantage of being very quickly handled and are used one under ch hub cap of the car to be raised. The lifting ram may be ad- sted to suit different wheel heights by means of a series of ratchet eth which enable the lifting link to secure either a long or a short ld on the ram member. In addition to the types of jacks shown, number of other forms have been marketed which do not give e quick lifting necessary for use in making repairs, but which e much stronger and better adapted for weight carrying purposes en the car is to be supported for any length of time. The form own at E, is composed of three substantial wooden legs, forming tripod and jointed together at their apex by angle pieces of steel. e lifting ram or screw may be raised or lowered by imparting mo- n to the nut resting *on top of the wooden tripod.* The form at F,

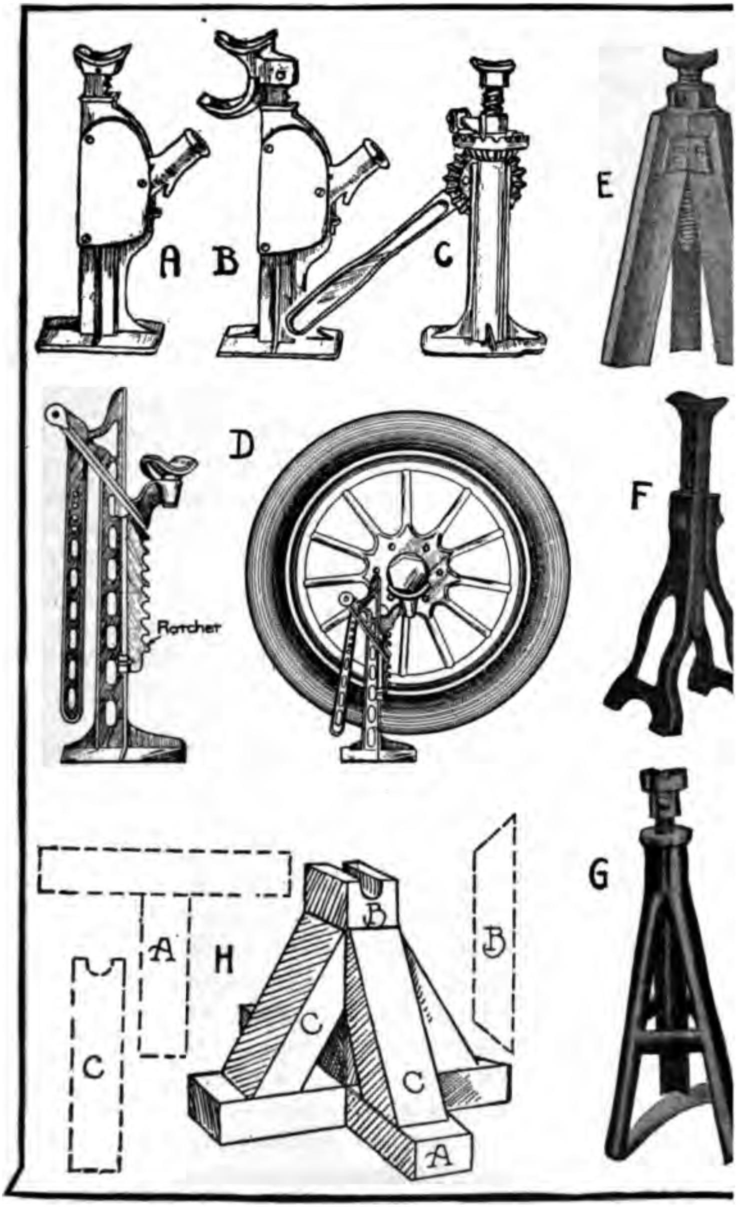


Fig. 16.—Practical Forms of Car Raising Jacks.

ed of three castings, the centre one being placed under le, while the two outside ones form the base of the device. it of the load-carrying member can be adjusted to a de- acing the clamping bolt which holds the assembly together the desired hole in the lifting ram. The form at G, is action to that at E, except that the tripod is a substantial made by slotting a steel tube at three points and then the legs apart and joining them by the brace pieces near The jack or support at H, may be constructed by any re- and is made of substantial timbers. The construction is so hown that further description should be unnecessary.

r repairman has occasions when it is necessary to take care which has met with some accident to the wheels, axles or knuckles, so that it is impossible for the car to proceed vn wheels. Towing such a car back to the garage is a ob if proper provisions are not made for supporting the nd of the car in a secure manner and yet one that will any appreciable friction. The common method of proce- a broken axle or wheel on a horse-drawn vehicle is to use beam as a support for the injured member, one end being o the good axle, while the other is allowed to trail on the This is not a good system to use with a heavy automobile, he friction between the end of the beam and the ground at that it will be a great strain on the towing car if the be moved for any distance. A simple emergency truck known as the Weaver Ambulance, and with which the laim one driver is capable of towing in a disabled car, is Fig. 17, A. The truck and one method of using it is d, and the marked feature is the ease with which it may ed and removed. Besides being used to support the front he car, as in the illustration, the truck may be employed stitute for any one of the wheels. The tongue portion is le to suit requirements of the work to which the device d.

ion has been previously made of the utility of a portable the repair shop. These are capable of handling a wide of work and it is a practical and not expensive sub-

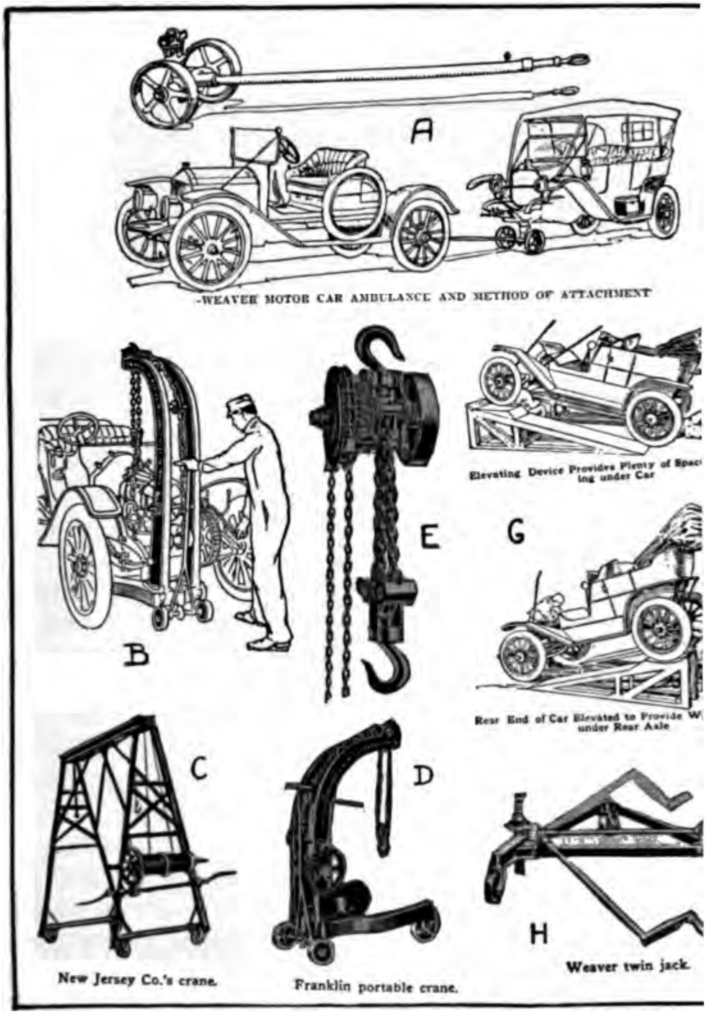


Fig. 17.—Weight Carrying and Lifting Appliances for the Repai

stitute for an overhead rail system. In the repair shop, stance, it has the special advantage of being able to get int that the overhead crane cannot reach. This form may b

ie work, whereas the work has to be taken to the usual over- trolley. It is of strong construction, and one man can handle thousand pounds by its aid, picking the same up with ease, sporting same, and placing it in any desired position. These es are made in various styles, the ordinary range of sizes ted for repair shop work varying from one to three tons' city. The crane shown at D is a very substantial and strong 1, and is shown in use lifting an engine out of a frame at B. ther form of portable hoist is shown at C. This is virtually gh trestle mounted on wheels and well braced. Two winding ns are used, each serving one lifting rope. Owing to the drum ation by small pinions and long hand cranks, the leverage is great, and one man may raise any load within the capacity he crane.

The need of some form of chain hoist in garages where the port- crane is not used is more marked at the present time than formerly the case when automobiles and their components e lighter than they are to-day. The rapid growth of the mo- truck industry also means that heavy pieces must be handled. ere it was formerly common practice to cast motor cylinders ividually and in pairs, it is now general practice to use 4 and ylinder block castings which are difficult to handle, especially he larger sizes.

The chain hoist also forms an important unit of all overhead ley systems, as a very effective travelling crane may be con- ed by using a simple wheeled trolley, running on a commercial ection beam and having a hook to which the chain falls may be ached. The Simplex chain hoist shown at Fig. 17, E, is a two- ed device permitting great leverage and slow speed for heavy ds, and greater speed, though lessened leverage, for lighter ght. As will be noticed in the accompanying illustration, an less chain runs over a chain wheel, which in connection with pinion and brake wheel with ratchet teeth in its outer rim ms an automatic brake to prevent the load from descending. The pinion attached to the hand chain wheel drives a spur gear, ch is keyed to a second shaft, at the end of which is another ion. The last named member engages with an internal spur

gear, which is keyed to the opposite end of the main shaft, which is attached the lift chain wheel. Motion is transmitt from the hand chain to the lift chain, and by pulling on t hand chain, in either direction, the load is lifted or lowered. Wh hoisting a load the brake wheel, with its ratchet teeth on t

Fig. 18.—Showing Practical Use of Portable Crane in Automobile Rep Work.

outer rim, rotates freely with the hand chain wheel and pin and without resistance, as the ratchet pawl runs freely over teeth. When the pull on the chain wheel ceases, the pawl eng with the teeth of the ratchet on the brake wheel, preventin from running backward, and so keeping the load suspended.

In lowering the load the hand chain is pulled in an opp

ion. and but little effort is required to overcome the friction e automatic brake, thus permitting the load to descend and ng the same suspended again, as soon as the workman stops ng on the hand chain. The load can be lowered at a good of speed by a continuous pull upon the hand chain. By s of an ingenious arrangement of the lower block, the lift is locked to the chain wheel of the lower block, providing wo speeds referred to, making for economy of time in handling loads. Closed rings attached to a swinging frame provide es for the hand chain, enabling the operator to stand away under a load, pulling the chain at an angle, without pro- ing any appreciable amount of friction or wear on the chain uide. The construction eliminates the possibility of the chain ging between the wheels and guides.

In many shops it is inconvenient to provide pits by which the kmen may gain access to the under portions of an automobile. ery practical elevating device which provides plenty of space working under a car is shown at Fig. 17, F and G. In the ner illustration the front end is shown raised, while at G the r end is elevated. This consists of a light, inclined runway le of planking and timbers upon which the car may be run. air of hollowed blocks at the upper portion in which the wheel fit provides a positive stop to prevent the car from rolling he stand.

Another useful device for use on the assembling floor that s considerable time when an entire end of a car is to be d, as is necessary for inspecting parts of the steering system ar axle faults, is shown at H. This is known as the Weaver jack, and consists of a triangular framework mounted on s and carrying two lifting screws actuated by bevel gears the base of the triangular frame. A cross shaft carrying r sized bevel gears actuates the lifting nuts on the vertical , and is in turn operated by a bevel gear turned by a , to which motion is imparted by a hand crank. The gear- so arranged that a large amount of leverage is provided e heaviest car may be raised without any exertion. The rank is mounted *in a swivelling bracket,* which makes it

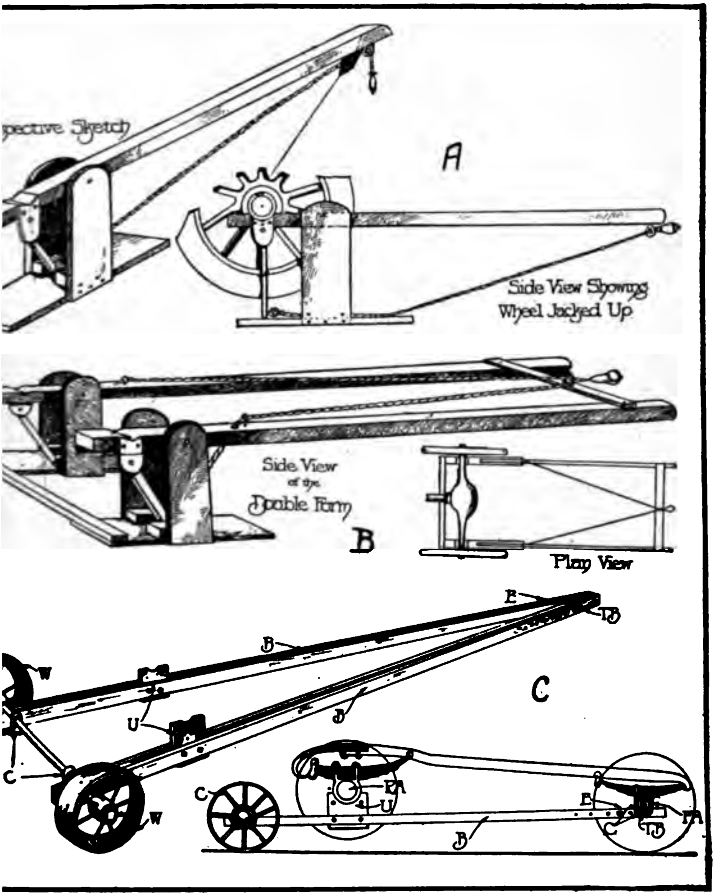
possible to operate the jack without stooping or to fold the handl over entirely out of the way. As the jack is carried on a wheeled frame, the car may be moved around even if the two wheels of the axle supported by the jack are removed.

A reader of "Motor Life" sends a description of a quick action lifting jack that is very well adapted for garage use, though too bulky to be included as part of an automobile equipment. This form has been widely used in connection with racing, as an entire front end of a car may be easily raised and held by the force exerted by one man at the end of the long lever when a quick tire change is necessary and where every second counts. The usual form of lifting jack operating on either the ratchet or lifting screw principle would require considerable time to raise the wheels clear off the ground, whereas the form depicted at Fig 19, A, will do the work in 15 seconds.

This consists of a handle or lever, 8 or 10 feet long, supported and pivoted between two uprights attached to the base. Underneath the front end of the lever is a swinging post which supports the weight of the car when in a vertical position. The size of the parts and strength of the lever will vary with the weight of the car. The base, uprights and handle may be of wood. The base should be about 20 inches long and 6 or 8 inches wide, having the uprights mortised into the sides and braced with blocks on the inside corners. The uprights may be about 4 inches wide, both these and the base being of 1-inch material. The height of these uprights and length of the post will depend upon the diameter of the wheel and the amount it is to be raised. Supposing that the distance from the ground to the underside of the hub or axle is 15½ inches and that the wheel is to be raised 3 inches, then allowing 1¼ inches for the thickness of the base, the length of the post will be 17¼ inches minus the thickness of the lever under the wheel.

This post or support may be made either of wood or iron and pivoted underneath the lever in any convenient manner so that it will swing freely. An iron rod with one end bent to form an eye may be obtained from any blacksmith shop for a few cents. A bearing may be formed for this rod either from woo

r heavy sheet metal attached to the sides of the lever n. The holes in these blocks as well as the eye in the nd of the post should be large enough to take a three- inch bolt. Another three-quarter inch bolt may be used ›rt the lever in the uprights. There will be considerable :tween the sides of the post and the blocks, and this may



—Quick Action Car Lifting Jacks and Truck for Use in Towing Disabled Cars.

be filled by using a number of three-quarter inch washers on bolt. The same method may be used to fill the space between lever and the two upright pieces.

On the top of the lever, directly above the support where hub or axle rests, a shallow V-shaped groove should be cut that the axle cannot slip off the jack when raised. The under of each end of the base should be rounded off so that the can be slid over the floor of the garage without the corners ing on projections. The operation of raising the wheel is simple, since all that is necessary is to slip the jack under the or axle so that the weight will come directly in the groove the support, when the car is raised by pressing down on outer end of the lever. Since the supporting post swings it will assume a vertical position when the car is raised, so when the weight is taken off the outer end of the lever the takes the entire strain of the load. In order to facilitate ing the jack from the car, a small wire rope should be att near the lower end of the post and run through a ring in outer end of the lever. Thus when the lever is pressed down post swings free and may be pulled back from under the wh

The jack is shown from two different viewpoints in illustr but it seems that the builder of this has not taken the fullest sible advantage of his opportunities. If, as he says, jackin is slow and tedious work, the device as shown only eliminat work of raising the car by means of the jack, and substitut it the task of prying up one wheel at a time, then putting or some firm and stable object of the right height under the next letting the jack down and moving to another wheel. the device as constructed, it would take four different ap tions to lift a car entirely clear off the floor, two at the rear close to each wheel, and two at the front axle, near each whe

It is possible to reconstruct the jack as outlined so this may be reduced to two applications, one for the rear axle one for the front. This is done by constructing the jack as outlined, but in duplicate, fastening the two together at front end and also at the rear. In addition, it will be nec to make the handle much longer and stouter, for whereas the fo

k lifted but 700 to 1,100 pounds or higher, according to the size the car, this one will be required to lift just twice as much every e, namely 1,400 to 2,200 pounds, according to the size and weight the car.

For this reason, also, it would be well to increase the propor- s all over. Devices of this sort have been built and used many racing contests, in which the smallest fraction of a und was valuable. The device in those cases was built of al throughout, light weight being of no object. When the al came for a tire stop on the next round, this was wheeled into a convenient position, and when the car stopped it was slid der the axle, a couple of men jerked it down, raising the entire e so wheels stood clear off the ground, and in less time than takes to tell it, another pair of men were replacing the wheels d tires, or tires alone, as the case might be. These were so made h definite proportions that when fully pressed down the jack uld stay down of itself and did not require a man to stand and d it.

A home-made cradle for bringing in cars having an injured e or wheel is outlined at Fig. 19, C. It can be constructed any mechanic of average ability from odds and ends, and as oes not take up much room it can be stored conveniently when in use, though many uses will be found for it in the garage, n when not employed for the purpose for which it was pri- ily intended. This consists mostly of a built-up pair of beams ning the two long sides of a very acute triangle, the third of which is formed by a pair of small metal wheels and an , such as might be found on any old farm wagon or other heavy k. The axle is securely attached above the side beams, which fastened together at the front. About 18 inches to 2 feet ard of this axle a pair of vertical supports are formed with tch in the upper surface large enough to take an ordinary axle. In the sketch, the side bars are marked *B, B,* the up- ts for the car axle *U,* the wheels, *W, W,* the clips holding the to the sidebars *C,* the forward ends *E,* and the tie bolt holding together and making a point of attachment *TB.* The second h shows the method of use; the cradle is pushed under the

chassis, so that the uprights catch the rear axle *RA*, then the fr end *E* and the through bolt *TB* are fastened to the front a *FA* by means of the chain *C*. This being the case, the rear wh of the car do not rest on the ground, but the small iron wheels, of the cradle do, and the car is pulled home on these and regular front wheels.

The same outfit can be used for an underslung frame by lay a board across in place of the uprights, and resting the r axle of the car on this. In doing this, the uprights must removed, so the board should be made with a pair of extensi and this bolted in place, using the same bolts as with the uprig A device of this kind has recently been placed upon the mar by a western firm, this being finished up very neatly all o while the sketch simply gives the idea for a more or less ro home-made cradle.

Machinery Equipment for Small Shops.—The amount of chinery used in repair shop equipment will depend entirely u the size of the shop and the character of the work it caters. The requirements of the average small shop will be met very by the use of a 16-inch screw-cutting lathe, a sensitive drill p an emery grinder or twin wheel stand, and a forge outfit. If classes of work are to be attempted, a small shaper will be f very useful, as much of the work that can be done on a mil machine can also be accomplished on the shaper, which is a costly machine tool. In all repair shops, irrespective of size, lathe is really the most important tool, and one good sized mac of this kind should be included in the equipment of any re shop worthy of the name, no matter how small. Practically classes of machine work may be done on a lathe, as very effic attachments may be obtained on the open market that will en a machinist to do milling, gear cutting, and grinding on this versal machine tool. Drilling may be done without changing lathe in any way. About the largest part to be handled in repair shop would be an engine flywheel, as far as diameter is cerned, and the longest piece would probably be a six-cyli crankshaft or live axle. It is not necessary to install a l *capable of swinging* 24 inches in order to have a tool avail

ork that would be unusual, as very effective results may ained by using a gap bed lathe which can be purchased at ight extra cost over that of the regular tools. The ad- ;es of this type of lathe will be considered in proper se- :. A lathe that will swing 16 or 18 inches will be suffi- r large for most shops, though it can be supplemented by ller size adapted for lighter work if the funds permit. In ; lathes, especially for a small shop where the machine tool nent is necessarily limited, it is well to remember that small an be handled in a large lathe much easier than large work : turned in a smaller one, and where it is imperative that ıe tool be purchased, it will be the best economy to install tantial machine. If a drill press is included, one that will 24 inches has been found large enough to handle nearly all of automobiles. The sensitive drill press is used for drill- nall holes, and should have a capacity so that it will handle up to a half inch diameter, at least.

ıchine Tool Equipment for Complete Repair Shop.—An un- y complete machine tool outfit is shown in the shop plans at 5 and 6. With an equipment of this nature all kinds of work may be accomplished economically and, in fact, the ; shown are sufficiently complete so competent mechanics will e to build an automobile without outside assistance. As the is the king of machine tools, the major portion of the equip- consists of these useful machines. Seven lathes are pro- two being ten inch swing, three fourteen inch swing, one en inch swing and one capable of handling work up to y-four inches in diameter. A universal milling machine upon a wide variety of work may be done is a useful adjunct to the. A milling machine can finish flat or irregular surfaces a lathe cannot do unless fitted with a milling attachment. ll make Woodruff keyways or straight splines, it can cut cams and do a variety of other work that cannot be done : simple lathe.

small shaper having about sixteen inches stroke is also l, because it will do much of the work done on a milling ne and require simpler tools. While a milling machine has

a greater range of work and will do it more economically th
the shaper, the latter can be used to advantage in many c
where the cost of milling cutters would be much more than t
of making the shaper tool and doing the work besides. B
milling machine and shaper should be provided, if possible. T
drilling machines are provided, one a sensitive drill for light w
the intermediate size, a back-geared drill press, and for extre
large work, such as drilling frames, boring cylinders, axle b
ings, etc., a radial drill is very useful, as it will handle any
of a motor car irrespective of size. A power hack saw, two
grinders, one used for roughing purposes and the other for
grinding, and an arbor press, complete the equipment of
machine shop.

Power for the Shop.—Just as electric current is superio
lighting, it also has many advantages as a source of power.
electric motor is an ideal power generator, because it is
efficient, economical, easily started and stopped, compact and
ble of standing considerable overload. It makes possible indiv
motor equipment of machine tools in large shops and can be
very effectively for driving the line shafting of the smallest
lishment, because it can be suspended out of the way on a pl
hung from the ceiling or in the smaller sizes placed on a
attached to the wall or some convenient post. Where e
current is not available and where it is not profitable to
a generating plant, the gasoline engine is an economical met
supplying power. The marked advantage of electric cur
that it may be employed not only for lighting, but for ope
various portable drills, polishing machinery, air compressors,
and it also has a great advantage of generating current that
be used for charging storage batteries, which are now included
the equipment of all up-to-date automobiles, as a source of cur
for the electric self-starter and lighting system. Where elec
current is not available from a municipal central station, a ga
or repair shop of any size will find it more economical to inst
generating plant and make its own electricity for lighting
power than to use a steam or gasoline engine which can only

sh power and then depend upon kerosene and acetylene lamps r lighting, which naturally increase the fire risk.

Small Generating Sets.—A typical generating set consisting a four cylinder gasoline engine driving a direct current dynamo shown at Fig. 20. The equipment is furnished in various sizes, d an outfit can be purchased that will furnish current econ-

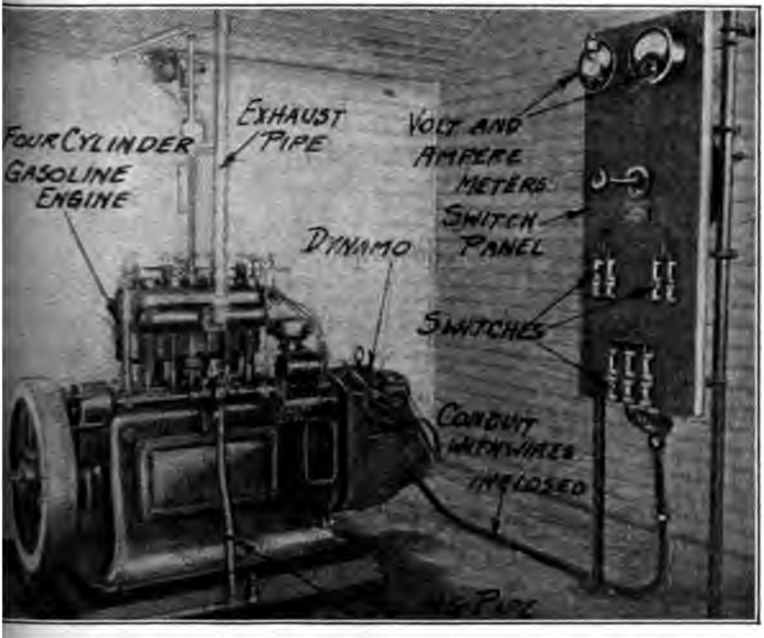


Fig. 20.—Isolated Power Plant for Generating Electric Current.

mically for even the smallest shop. The outfits include switch-oards and all necessary governing and control appliances, and once he engine is started it requires no further attention, as it will erform the various functions incidental to controlling its speed nd power automatically. Instead of using the line shaft, as would e necessary with a gas engine belted direct, it is possible to in-tall individual motor drive on the various machine tools, an xample of which is shown at *Fig. 21.* *When one* considers that

the average line shaft consumes from 20 to 30 per cent. power delivered to it in journal friction, if any number of l are used, or if the shaft is not absolutely aligned, it will be ent that the use of individual motor drive will reduce this loss appreciably. When only two or three machines are driven, it is, of course, more profitable to drive these from length of shafting than it would be to provide a separate

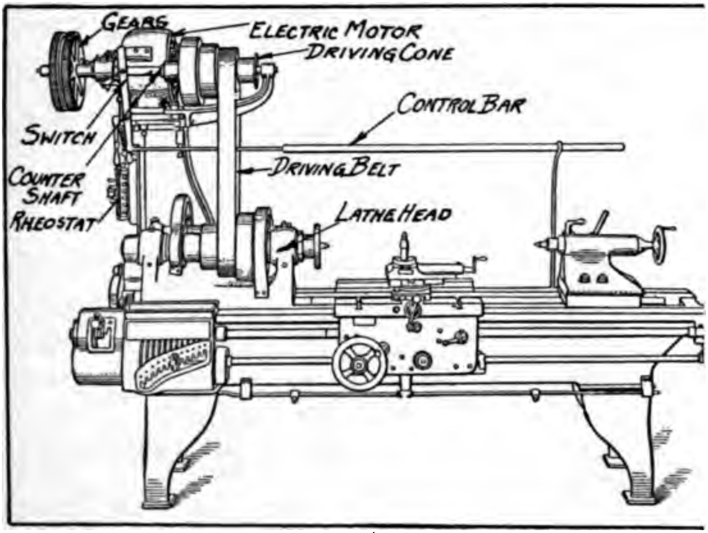
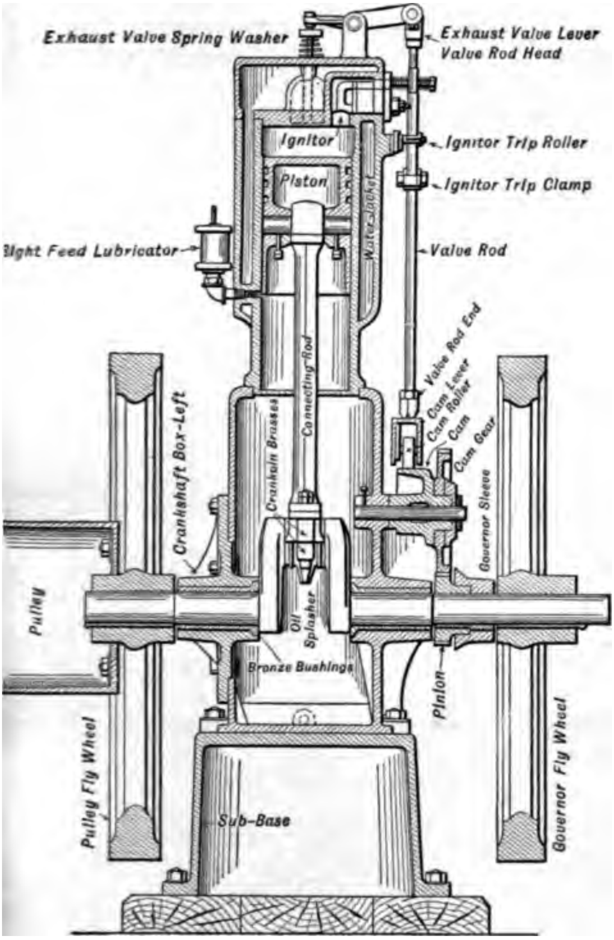


Fig. 21.—Form of Lathe Adapted for Direct Drive from Electric

for each machine tool, as one motor may be made to serv all where the power requirements are not great.

The writer does not mean to imply that the interna bustion motor in its various stationary forms is not adap power delivery in small units, because many repair shops having a very complete equipment, obtain their power (from an oil engine which is the most economical of the power-generating units. When a generating set is used necessary to use an engine of greater power than would be if belted directly to the shaft line, but as in most insta



2—Sectional View of One Cylinder Vertical Gas or Gasoline Engine Suitable for Automobile Repair Shop Power Plant.

the electrical current is to be used for lighting as well as : it is, of course, necessary to provide an actual surplus ov power needed to run the shop in order to furnish the curre illumination.

As practically all automobile mechanics are familiar wi explosive motor, owing to its almost universal use as a

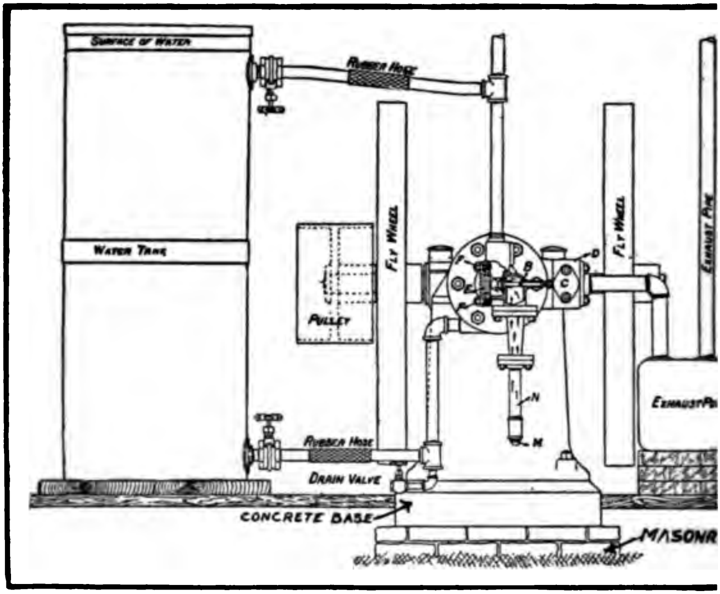


Fig. 23.—Outlining Method of Installation of Stationary Gas or Ga Engine for Shop Power.

mover in automobiles, it is reasonable to expect that many is repair shop owners will avail themselves of the opportuni use a source of power with which their workmen are thoro familiar. A one-cylinder vertical engine adapted for stati power is shown in section at Fig. 22. Two large flywheel used to insure steady running, and the power generated m delivered to the shop line shaft by direct belt connection be the engine pulley and a corresponding member on the shaft.

of installing a horizontal engine adapted for stationary nd the provisions made for cooling the cylinder and dis- the exhaust gases are so clearly shown in Fig. 23 that it :essary to describe the installation further. For the very op using but few machine tools, it is not necessary to use e of cooling system required by the larger powered en- s the two or three horse-power necessary to operate a the, drill press and emery grinder can be delivered eco- ly from the hopper cooled such as shown 24.

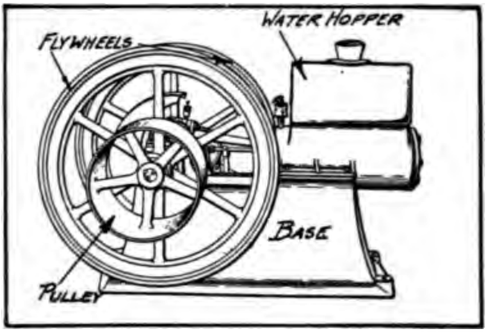


Fig. 24.—Gas Engine Suited for Small Repair Shop.

re a gas or gas- gine is used for it is necessary ide a substan- indation com- f masonry and as shown at , or of heavy as shown at in order to prevent excessive vibration of the floor. If pos- e engine bed should not rest on the floor, but the foundation e carried down to solid earth. The smaller hopper cooled of two or three horse-power may be bolted directly to the or, as these will not vibrate enough to be objectionable. A advantage of an isolated generating set such as shown 20 is that it may be housed in a structure separate from ir shop proper, reducing the first risk, whereas, where an is belted directly to the line shaft, it is usually in the ilding as the machinery it drives.

of the important advantages accruing through the use of gasoline engine is in the economy of this form of power. ngine is used capable of running on fuel oil instead of , there will be a marked saving, and the absolute limit in cost of power production will have been reached, the ms of power showing to better advantage being those de-

rived from natural sources, such as wind and water, neith which can be applied universally. The table of power cost sented herewith shows the relative expense of various form power among which are included three forms of steam engine gas engine using manufactured or natural gas, the internal bustion motor using gasoline, the electric motor and the oi gine. Where the power requirements are not severe, the g gasoline engine in the smaller sizes will not prove so expe to operate as to call for the use of an oil engine which is n easily started or kept in operation as the forms burning derived from the various gas-producing methods or by the v ization of volatile hydrocarbons, such as gasoline.

TABLE OF POWER COSTS

Type of Power	Kind of Fuel	Price of Fuel	Fuel Consumed per Horse-Power per Hour	Cost per Horse-Power per Hour	Cost per Horse-Power per Year of 300 Days, 10 Hours per Day	Cost of Generating Electricity, per Kilowatt Hour (Generator Efficiency 89½ per cent.)
Steam Simple Engine	Bituminous Coal	\$3.00 per ton	8 pounds	\$0.01200	\$36.00	\$0.01800
Steam Compound Non-Condensing	Bituminous Coal	\$3.00 per ton	5 pounds	\$0.00750	\$22.50	\$0.01125
Steam Compound Condensing	Bituminous Coal	\$3.00 per ton	3 pounds	\$0.00450	\$13.50	\$0.00675
Gas Engine	Illuminating Gas	\$0.75 per 1,000 cubic feet	18 cu. t.	\$0.01350	\$40.50	\$0.02025
Gas Engine	Natural Gas	\$0.30 per 1,000 cubic feet	12 cu. ft.	\$0.00360	\$10.80	\$0.00540
Gasoline Engine	Gasoline	\$0.12 per gallon	1 pint	\$0.01500	\$45.00	\$0.02250
Electricity (Motor Efficiency 85 per cent.)	....	\$0.02 per Kilowatt hour	$\frac{878}{1,000}$ kw.	\$0.01760	\$52.50	....
Oil Engine	Fuel Oil	\$0.02¼ per gallon	1 pint	\$0.00280	\$ 8.40	\$0.00420

er Required for Machine Tools.—The amount of power rovided in a repair shop depends entirely upon the char- d number of machines to be driven. If a line of shafting used to turn the machinery, and especially if there are ial countershafts for each machine, as is needed for most shop tools, it will be necessary to double the power re- nts of the tools used, as given in the accompanying tabu- to take care of loss of power through belt slip, journal , lack of machine alignment and other causes. The figures re taken from the best mechanical authority and are an of some widely different estimates for the same class of e.

Energy Consumption of Common Machine Tools

Machine	H. P.
itive Drill	.32
k Gear Drill Press (20″)	.42
k Gear Drill Press (30″)	.45
ial Drill (medium size)	1.12
Lathe	.26
Lathe	.38
Lathe	.44
Lathe	.65
ed Lathe	.15
ling Machine (small)	.19-.29
ling Machine (large)	.83
per (14″)	.35
per (24″)	.52-.70
ner (small)	.00
ner (medium)	.50
l Grinder (one wheel)	.97
l Grinder (two wheel)	1.15
vy Roughing Grinder (two wheel)	1.90
shing Stand (High Speed)	1.00
ver Hacksaw (12″ to 14″)	.06

tallation of Machine Tools.—The placing of the machinery pend entirely upon the ideas of the master mechanic and t method of installing line shafting will, of course, depend he character of the building *and the materials* of which the

wall or ceiling to which it is attached is constructed. If t floor space permits, the machinery should be arranged so that may be driven from a single main line of shafting. It is w to remember that a reduction of the length of the shaft and number of hangers for its support decreases journal friction a consumes less of the shop power. If the machines are on ground level, as is the case with most small shops, the floor m be made of heavy planks, attached to substantial beams laid o a foundation of cinders or well grouted crushed stone. A floor cement should always be planked over because the wood floor is much easier on the feet of the workmen. It seems alm unnecessary to mention that a perfectly level floor should sought for. It is imperative that the floor be substantial enou so it cannot vibrate and have sufficient strength so it will deflect under the weight of the machine tools. There is so danger from this source, if the machine room is placed on upper floor of a converted building that has not been especi constructed for automobile repair work. All machinists and m wrights agree that the foundation for the bed of a machine sho have no deflection, if the life of the machines and the accur of the work performed upon them is to be given considerati The problem is considerably simplified when one considers t in automobile repairing, machine tools of great weight are used, so there should be no difficulty due to either floor vibrat or deflection in any ordinarily well constructed building.

The floor plans presented at Figs. 3, 4, 5 and 6 inclusive s logical arrangements of machine tools that can be followed advantage. The lathes, milling machines and shapers should installed where there will be plenty of light upon them, and is well to group all lathes together, if possible. Drilling boring machines must be installed with ample floor space aro them so the large work can be handled to advantage. A room should be allowed around each individual machine, and t should be sufficient space between the benches and tools to a the workmen at the bench to pass between the operator at machine and the bench with room to spare. An ideal met of installing an electric motor, if this is used as a source

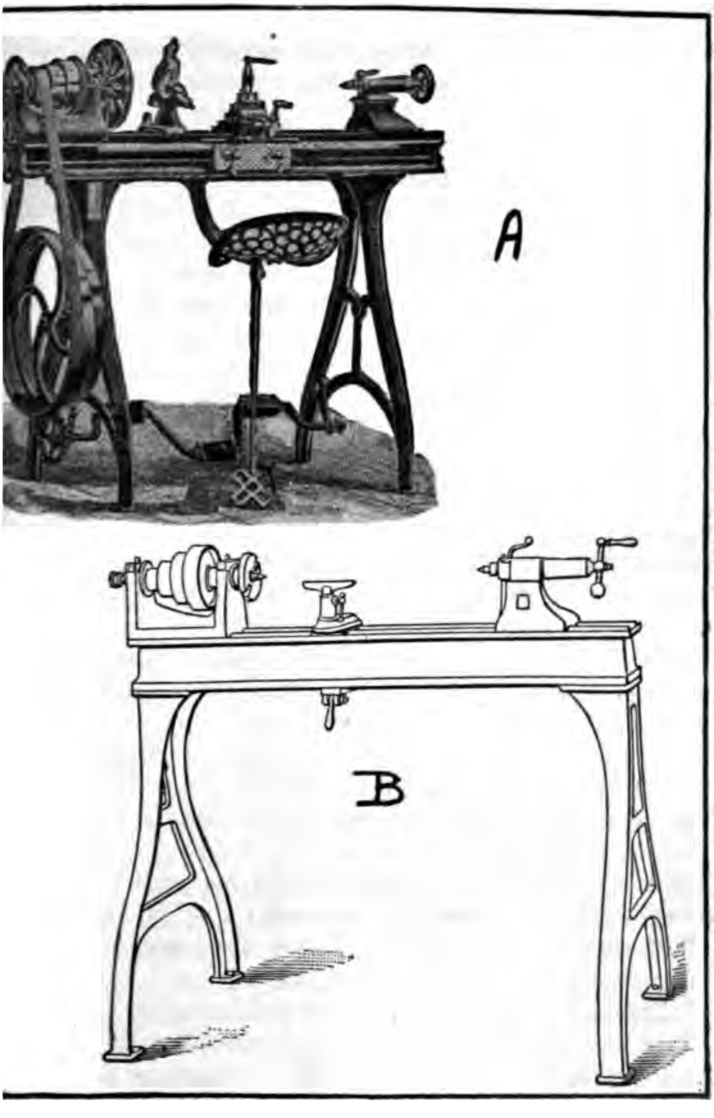


Fig. 25.—Simple Forms of Lathes.

power, as would be the case in any city or town where cent station current was available, is to support it on a stout platf suspended from the ceiling at any convenient point and to m a direct belt connection with the main driving pulley of the l shafting. The proportions between the motor armature pul and that on the line shaft should be such that the speed of shafting will not exceed 300 R. P. M. The switches, start rheostats and fuse blocks should be placed on one panel at convenient height on the wall. As an electric motor needs l little attention, in some shops it is hung directly from the ceili i.e., the base is securely attached to the beams by lag screws. precaution is taken to change the location of the lubricating wells under the main journals, a motor can be operated just well upside down as in any other position. Where central stat current is procurable and but few machines are used, the in vidual motor equipment does not have the advantages in a sm establishment that are presented in its favor when used in the la manufacturing enterprises. While an individual motor for e machine eliminates a large amount of overhead shafting, belt etc., and conduces to a lighter and cleaner shop, it is doubt if the advantage of rendering each tool or machine independ of the others as regards power would compensate for the cost such an equipment. It is doubtful if individual motor drive wo be an economy in the repair shop if one considers that most c panies supplying current make a fixed service charge, this b figured so closely that it is almost as cheap to keep a low po motor going all day as to keep shutting it off and on or usin varying number of smaller motors having in the aggregate so what less power. Besides, in a repair shop of any size, it is likely that there will be any lull in the work. and power wo be required from morning to night.

The Lathe, Types and Accessory Equipment.—Two very sim forms of lathes which are better adapted for the private gar repair shop than for general work are shown at Fig. 25. Tha A is a foot power machine that is capable of doing very fine w and that is well adapted for experimental and light repair p *poses.* It will swing nine inches and has a space of 25 i

ween centers. The tail stock can be set over for taper turning, d a swivel tool carriage permits a wide range of work. It is vided with a lead screw and is suitable for thread cutting. e lathe at B is a small speed lathe that is shown with a tool t adapted for hand-turning tools. This can be replaced by the al form of cross slide rest, making it suitable for metal turning rk. A small lathe of this nature is included in many repair ops for wood turning and is often fitted with a drill chuck and d in place of a sensitive drill for light drilling. A machine of s kind is inexpensive and very useful. The light screw-cutting he shown at A is also furnished with a countershaft, making suitable for power drive, though a surprising quantity of accu-te work may be accomplished without unduly fatiguing the erator, if the foot power form is utilized.

All lathes, with the possible exception of the speed lathe, in der to be thoroughly practical for repair shops, should have ew-cutting attachments, elevating compound rests, hollow spin-es and a good outfit of auxiliary attachments. Several sizes of cks and face plates, and a steady rest and back rest for long rk, should also be provided. A lathe that will cut from four forty threads per inch has sufficient range for all ordinary p work. A number of different designs of lathes of latest ttern suitable for repair shop use are shown at Fig. 26. That A is the conventional form of engine lathe that has been so versally applied in the machine shops of the world. It is back red and provided with a complete set of gears for screw cut-g. The difference between this lathe and that shown at B is the change speed gear box provided, by which any desired ed of travel of the carriage may be obtained by merely shifting lever. In the form shown at A it is necessary to remove the iving and stud gears, and in some cases the lead screw gears, d replace them with others for varying classes of work. In form at B any desired gear ratio within the range of the d may be obtained by the simple movement of a gear-shifting er.

The lathe at C is a gap bed type, one of which should be in-d in the equipment *of practically all repair* shops, and if

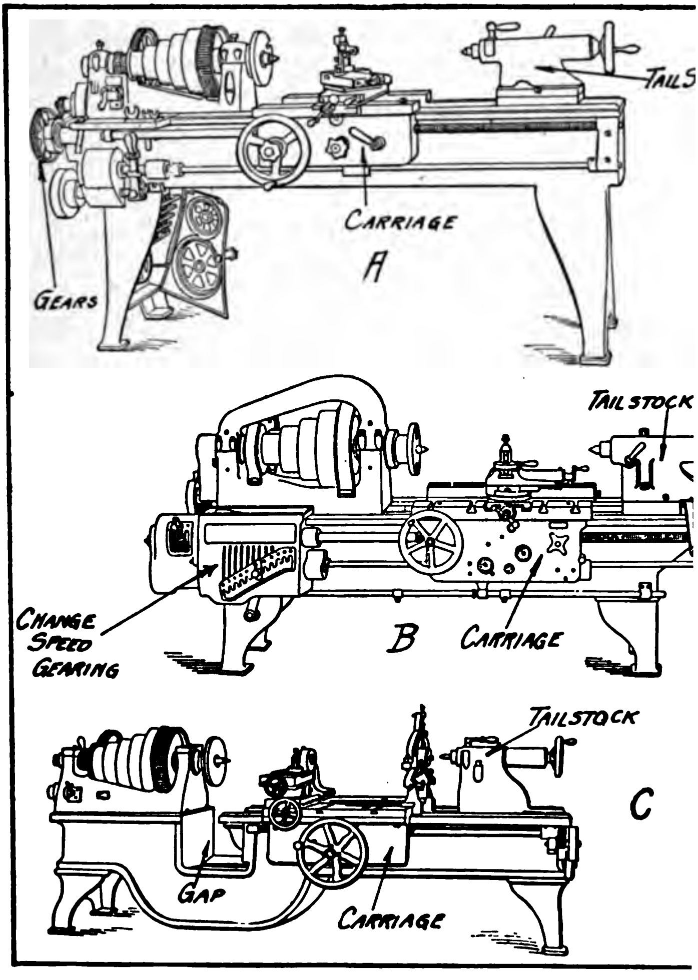
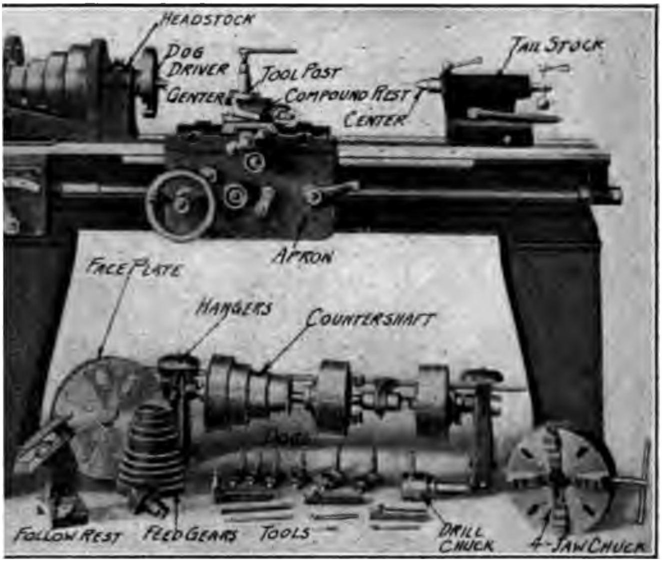


Fig. 26.—Outlining Practical Designs of Lathes for Automobile Shop Use.

only one lathe can be purchased this should preferably b(type. The gap in the lathe bed makes it possible to swir larger work than would be possible in either of the form at A or B, and a well designed gap bed will not be apr

in the solid bed form. All ordinary work may be . a lathe of this form, and in addition, the out-of-the- ›bs, such as machining a flywheel, facing a large clutch ıte, etc., can be accomplished when desired.
plete outfit suitable for most of the requirements of d general repair shops, which sells for approximately



ypical Screw Cutting Engine Lathe with Complete Equipment Adapted for Automobile Repair Work.

›wn at Fig. 27. This includes a 13-inch swing x 5½-foot ›eared, screw-cutting engine lathe. It is provided with ongitudinal and cross feeds. The cone pulley has four two inch belt. The ratio on the back gearing is 7 to 1. ›ck is cut away to permit the compound rest to be swung)0 degrees, and is fitted with a sleeve, bored to conform ıper No. 4, and has a self-discharging center. The tail ɔe set over for taper turning. The cross feed screw has 1 collar so the feed may be *regulated to* one-thousandth

of an inch. Change speed gears are furnished to cut threac 5 to 36, including 11½ pipe thread and one extra con gear to cover all special threads from 3 to 72. The special equipment consists of the parts outlined in illustrations. are large and small face plates, follow rests, steady resi pound rest, centers, wrenches, full set of change speed double friction countershaft, four jaw independent chucl

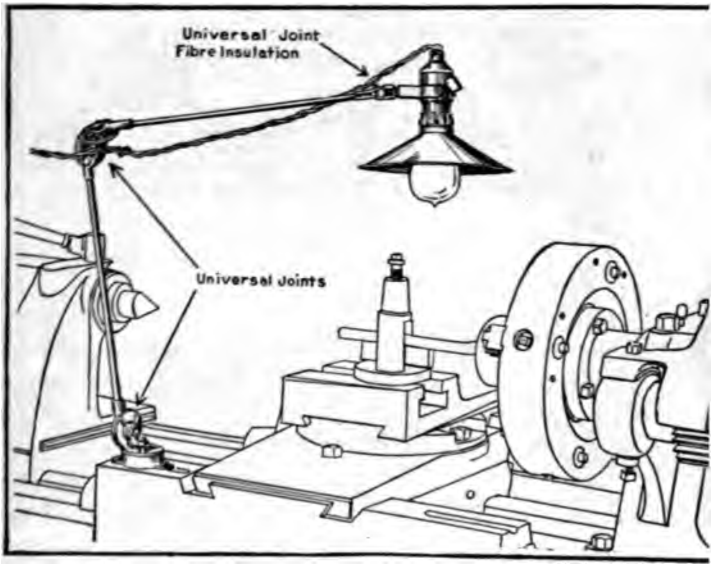


Fig. 28.—Useful Lamp Supporting Bracket for Use on Lath

chuck, set of lathe dogs, and a set of turning and boring too equipment of this nature is not only practical, but if the co outfit is purchased the garage man is sure of obtaining a pı machine tool for all ordinary repair work. The outfit shown be the same regardless of the size of lathe purchased, exce the auxiliaries, such as face plates, chucks, and tools, wo all properly proportioned for the machines they were to t with. In purchasing a number of lathes it is not necess buy a full equipment for each lathe. For instance, two

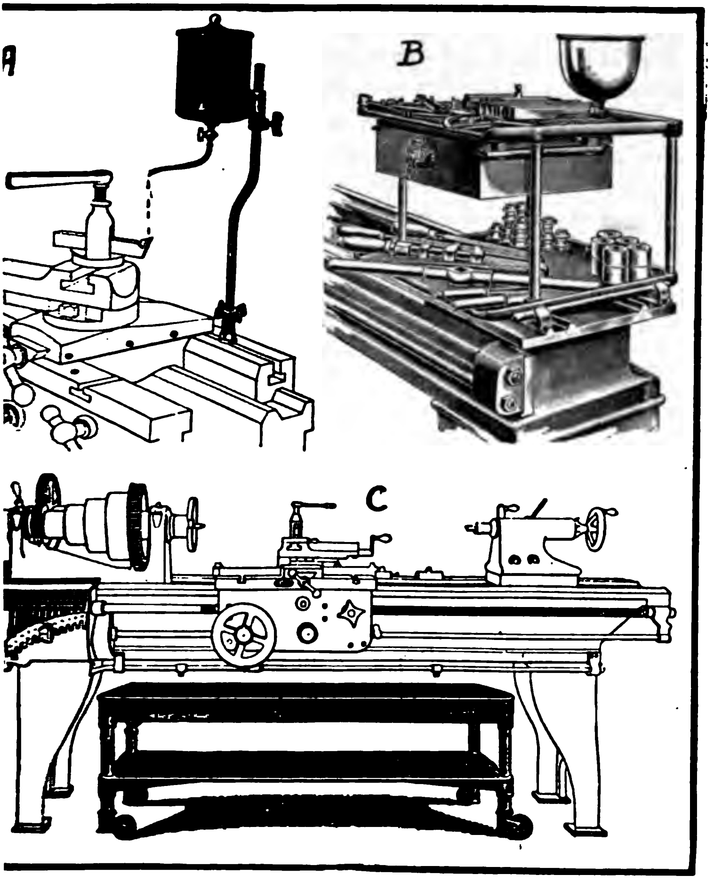


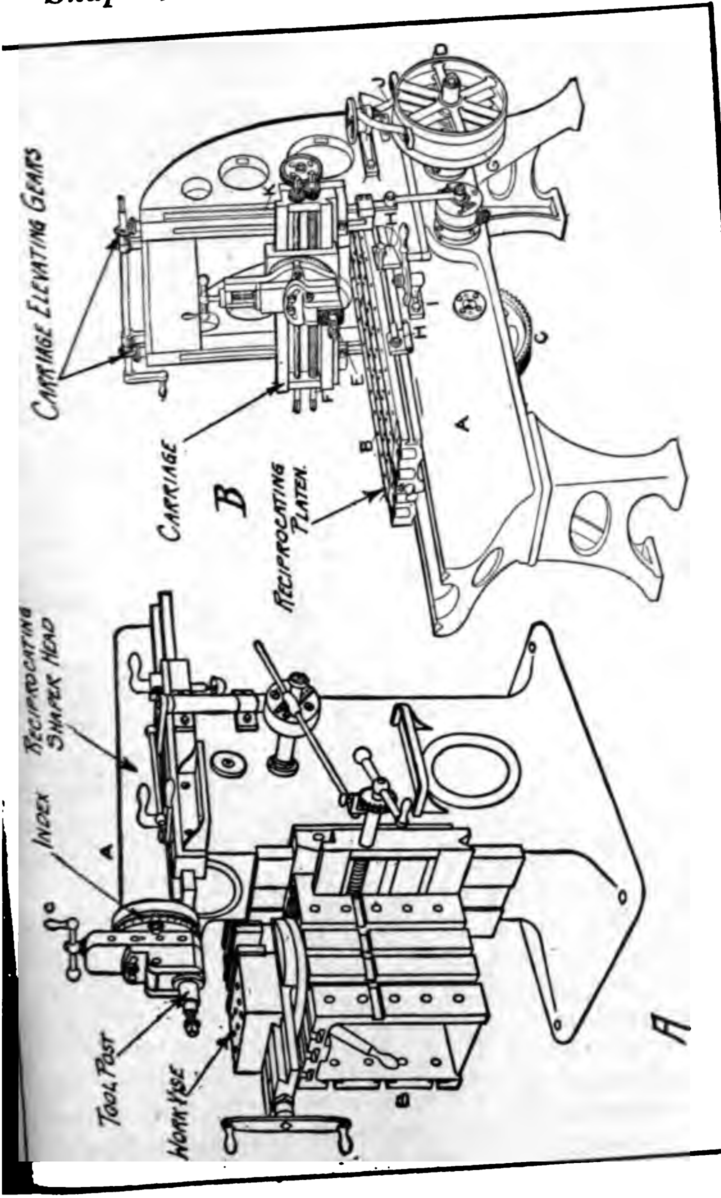
Fig. 29.—Useful Appliances to Facilitate Lathe Work.

o face plates would be enough for four lathes if these were same size. The follow rest and steady rest, which are not ntinually and forming the part of one lathe outfit, would, se, be suitable for any others of the same pattern. The types of lathe tools, chucks, etc., will be considered more th in the next chapter, which deals with the small tool ent of the shop.

the is not complete *without a number of* additional con-

veniences, such as shown at Figs. 28 and 29. The importan of proper illumination of the work is apparent, and this may b assured by using a universally jointed incandescent lamp suppo such as shown at Fig. 28. The universal joints make it possib to set the lamp at any desired angle and at any point that is mo convenient for the operator within a wide range. When cuttin resisting materials, such as the alloy steels used so widely in aut mobile construction, as well as when taking roughing cuts, th lubricant container shown at Fig. 29, A, is of value, as it no only is capable of ready attachment to the lathe carriage, but wil direct a constant stream of lubricants or cutting compound on th point of the tool in order to prevent it from becoming overheat As the container is supported by the carriage, it must move i proper relation with the cutting tool. The rack shown at B i an important adjunct, inasmuch as it provides a place for holdin the machinist's tools where they will be accessible and yet out o the way. The base of the rack is designed to fit the lathe shear and will keep various wrenches, files, etc., out of contact with th lathe ways. A drawer is provided, which may be locked, in whi the machinist can keep his finer tools, such as the micromete calipers, etc. Another adjunct to the lathe is the tray mount on a wheeled stand shown at C, designed to be placed under t lathe bed to catch chips and borings of metal and keep the from the floor. Its construction is very simple, and as it is ma entirely of metal, it is durable and fire-proof. The various artic of equipment outlined are marketed by the New Britain Machi Company.

Shapers, Planers, and Drilling Machinery.—Both the shap and planer remove metal from flat surfaces, whereas the lathe essentially a tool for machining cylindrical surfaces. In the shape which is shown at Fig. 30, A, the work is mounted in a fix work-holding vise, while the cutting tool is carried in a tool p mounted at one end of the reciprocating shaper head. The wo may be moved laterally by hand or power feed, while the t may be raised or lowered to get the depth of cut by the lever The tool post is mounted on an index so that it may be set at a *desired angle.* As previously stated, much of the work that



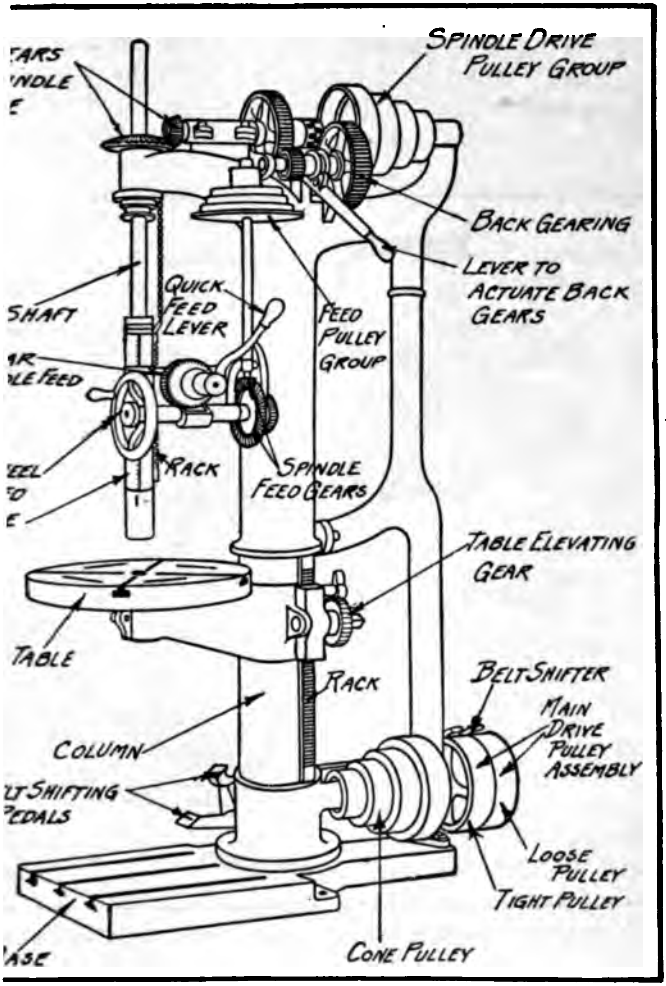
...and Planer. Two Machine Tools of Utility in Motor Car Restoration.

be done on milling machines can also be performed on the shap with less expensive tools.

The planer, an example of which is shown at Fig. 30, B, better adapted for handling large work than the shaper. In planer the tool is fixed relative to the work, except as relates vertical or lateral feeds. The tool is clamped in the tool post which is provided with an index fixture similar to that of the shap and a hand feed lever for setting the depth of cut. The to post carriage may be moved up or down on the supporting stan ards by means of a hand crank which operates the bevel-raisi gears. The work to be machined is secured to the planer b or platen B, which slides upon the ways machined in the bed As will be evident, the work is brought against a fixed cutting to whereas in the shaper the work is fixed and the cutting tool recipr cates over the work surface. A planer is useful in machini large objects such as motor crank cases, gear boxes and machini the flat surfaces on cylinder castings.

The drilling machinery provided should include a back-gear drill press having a table capacity to swing 24 inches. A typi machine of this nature of good design is shown at Fig. 31. T tool should be back geared, meaning that the spindle speed m be slowed down for handling large drills or doing heavy wo It should have both hand and power feed and a table adjust for both height and position. In the machine shown the table m be swung entirely clear or off to one side and large work suppor directly on the base which is provided with slots capable of tak T-bolts. The spindle which holds the drills may be raised by a ha lever for quick feed, by a hand wheel acting through worm ge ing for slow feed and by level gears for power feed. The spin drive shaft is provided with a keyway and passes through main drive bushing which is driven by bevel gears at the top of column. A drill press may also be used for boring and will han large work that cannot be conveniently supported in a lathe.

A large variety of milling work can also be done if a milli machine attachment such as shown at Fig. 32, A, is provid This has a circular base about 12 inches in diameter and a t 16½ inches long x 6½ inches wide. A longitudinal feed of



1.—Medium Size Back Geared Upright Drilling Machine.

. cross feed of 7 inches is provided by the fixture itself, , of course, be increased somewhat by swinging the drill ıe *table of the attachment* is provided with slots for *nch T-bolts for clamping* work, and the vise jaws prc

vided have an opening of ten inches. The table is provided an index support so the work may be set at any desired angl

If possible it is well to provide a smaller drilling machine ing hand feed only, which is known as the sensitive drill press. should have three or four speeds and be capable of taking dril

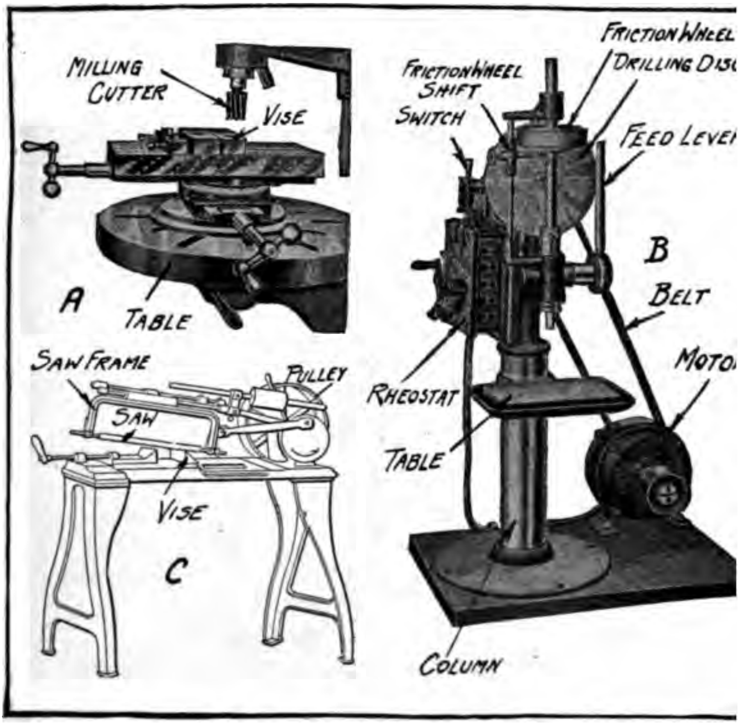


Fig. 32.—Practical Machine Tools for Small Machine Shop.

to at least three-eighths of an inch in diameter. The table sl be adjustable up or down and sideways, the arm should swi the right or left and should be of the type that permits one t either a V-block or cup to support bar stock in its place. A form of sensitive drill that is suitable for use on the work l and which is electrically operated by a small motor is shov

;, B. A variety of speeds is obtained owing to the friction The starting rheostat and switch are mounted conveniently ase permitting secure attachment to the bench.

iong the smaller appliances that are comparatively inexpen- nd yet very useful may be mentioned the power hacksaw, is not only simple but consumes very little power and is iatic in action after once being started. It occupies but little space and is very useful in cutting pieces from bar stock, such eel, iron, or brass more than an inch in diameter. A typical r hacksaw is shown at Fig. 32, C. This consists of a frame, rocated by a crank, which imparts its motion to the saw ie through the medium of a connecting rod. The crank is ed by a pulley which is usually belted direct to a very small ey on the line shaft and which turns at a speed considerably r than that member. The feed is automatic and may be varied altering the position of the weight regulating the amount of sure with which the saw bears against the work. The piece e cut is securely held in a vise attached to the bed of the ma- ie which is supported on cast iron legs in order to raise it to a venient height from the floor. A simple trip is provided, so t when the piece is sawed through, the drive will be interrupted . the saw frame will remain stationary.

An arbor press of large capacity is almost a necessity, and in n the smallest shops some kind of a press is essential for making ce or press fits, removing parts forced on, straightening bent es or tubular housings, and for removing arbors from parts ma- ned on the lathes or millers. A press capable of exerting 10 15 tons pressure will be sufficient to cope with any work brought o the ordinary shop. One or two smaller arbor presses can be d to advantage and should be mounted directly at the ends of large lathe beds, these serving to straighten small parts, such valve stems, etc., and to do light work in making force fits, and inserting and removing arbors from all work in which these are cessary.

A number of different designs of arbor presses are shown at g. 33. *That at A, has a distance* between screws of 20 inches and *istance between the head and* table of 36 inches. Its capacity

is one hundred thousand pounds and it weighs 870 pounds a very convenient press for use in the automobile repair sh its construction makes it specially well adapted for pressing into and from pulleys, flywheels, gearhubs, etc., and a straightening automobile shafts. The engraving shows tl

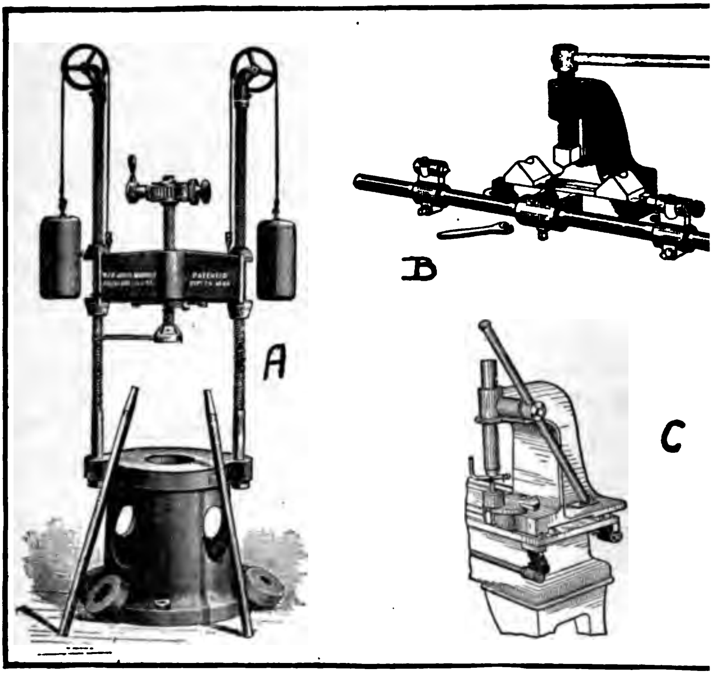
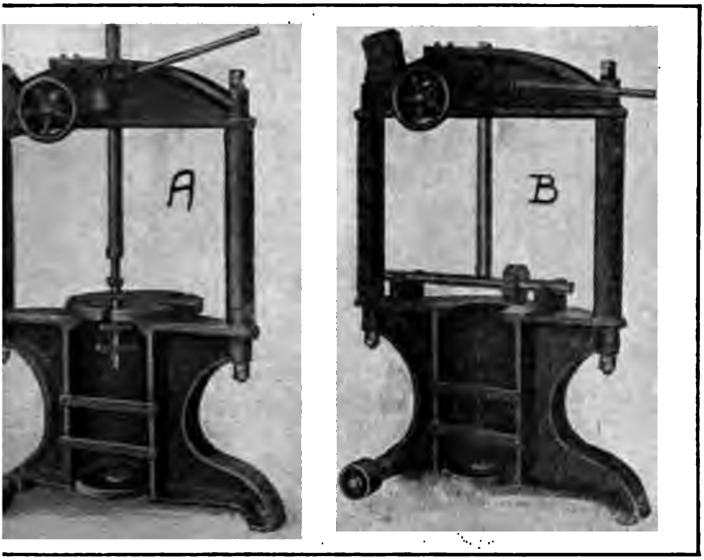


Fig. 33.—Showing Construction of Arbor Presses and Shaft Straigl Machines.

struction and principle of operation of the machine very dis Two large guide screws rise from the table upon which tl head is adjustably supported, as it has two semi-screw nı toggle mechanism by which the cross head is held fast or ı for vertical adjustment. The cross head is balanced by ٦ as shown, and a steadying bar connects the press cup with tl screw. A spur-toothed ratchet wheel is fixed on one end

rew, this being embraced by a forked lever head fulcrumed ate on the press screw. A double acting spring pawl en- ie teeth of the ratchet, and a hand crank is attached to the rew in order that it may be raised or lowered quickly, if

After the object has been placed in the press, the cross which the central screw is mounted can be instantly dropped work, and with a few turns of the screw the required pres-



.—**Arbor Press Design of Special Value in Automobile Repair Shop.**

iy be applied. An important saving in time is thus effected, ed with the method where a number of blocks must be on the bed plate to raise the object sufficiently to be acted the press screw. Tapering squared sockets are provided in d of the pawl carrier to permit the introduction of the long nown leaning against the press base, which will provide a eat leverage on the screw. The small arbor press shown at the Greenerd type and is intended to be placed on the lathe

shears where it will be handy to the operator. Such a press useful for small work.

For straightening shafts a special form of press is pı which is superior for that work as it is designed for it. A shaft straightener is shown at Fig. 33, B. As will be notice very similar in construction to an arbor press, except that tl is provided with a slot in which V-blocks are placed to supp shaft. Another V-block is attached to the end of the scr

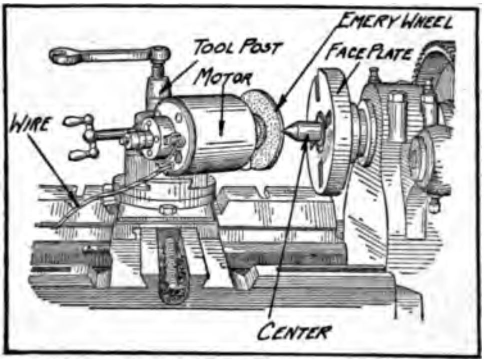


Fig. 35.—Electrically Operated Grinding Attachment for Lathe Toc

bears upon the shaft. In order to ascertain if the shaft is pı straightened, a pair of centers are mounted in front of the p a long bar attached to its base. As a shaft must be pla centers a number of times in straightening in order to obse progress of the work, the combination shown is evidently s for the purpose. With the usual form of arbor press the sha be taken to a lathe and swung between the centers after eacl ing operation. The process of shaft straightening is a compaı simple one, as it is revolved on centers and the high spot in by holding a piece of chalk against the shaft surface. Tl spot is then placed directly under the press screw and the p brought to bear against the shaft will tend to straighten it to its two point support.

Another very good form of press for repair shop use is sl

34. At A, the method of removing gears from a shaft is shown, at B, the press is depicted straightening a shaft. The press ily handled, as a small hand wheel is provided on the front machine to run the ram quickly up or down. This press has inch space between uprights, a 12 inch opening under the , 26 inch over the plate and 48 inch over the lower plate ble. Being mounted on wheels the press can be easily moved ny portion of the shop to straighten an axle or over a trap hole ugh which a crank shaft may be placed to remove a flywheel. auxiliary plate at the bottom of the chamber under the re- ing plate has a revolving centre and is very convenient when ded. The centre of this plate is provided with a self-centering face or a spherical or ball joint which will insure steady press- on the centre line of the press even if the work is tilted slightly n it is initially placed. With this press one man can exert ressure of ten tons and two men sixteen tons. With the lever- form, the workman is able to "feel" what he is doing, therefore danger of applying excessive pressure is avoided.

pecial Tool Attachments of Value.—Many special devices can sed to facilitate machine work which should be included in the pment. In automobile repair work many irregular pieces are dled, and it would seem to the writer that a set of universal plates, which could be used with equal facility on the bed e drill press or shaper or on the face plate of the lathe, would n excellent investment. Then there are the index heads, which be mounted on almost any machine tool, and which enable to cut gear teeth, mill slots, or drill holes at regular intervals nd the periphery of a circular piece, without time spent in g out. The vises for holding work on the drill press or r should be a pattern that they can use on the face plate e lathe, and two or three different sizes can be employed vantage. Special boring bars, cutters, and grinding wheels ld be provided, as needed. A small portable electric motor hown in Fig. 35 mounted on the lathe tool rest can be l in grinding, both internal and external. For the sharp- g of drills, cutting tools, reamers, etc., small universal bench ers as at A, Fig. 36, *driven directly by small* electric motor

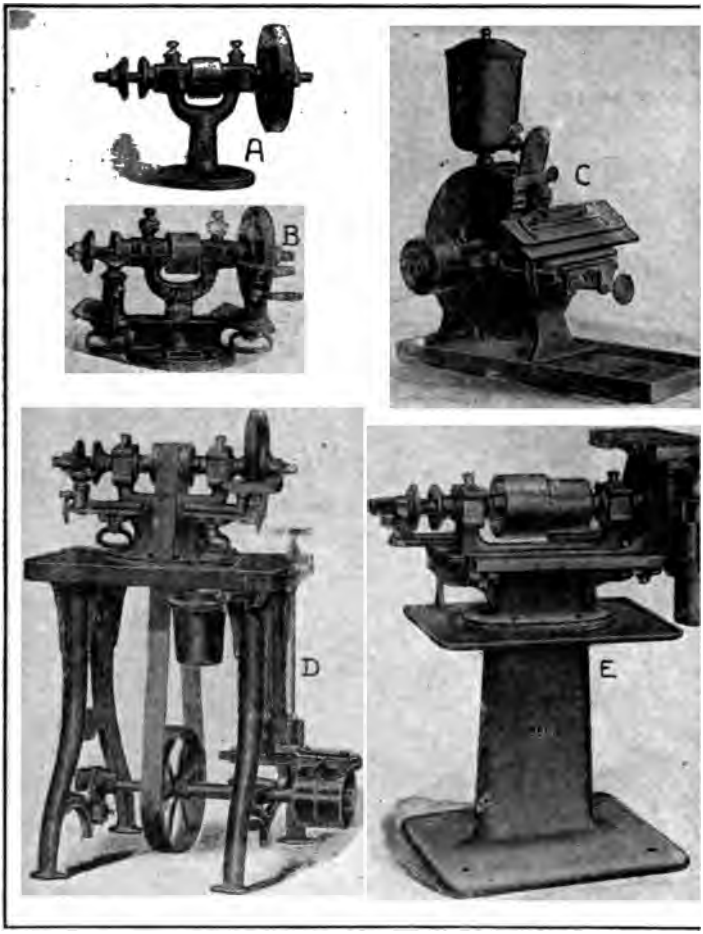


Fig. 36.—Practical Forms of Grinding Machinery.

or by belt from the line shafting, cna be profitably installe
equipment of drills, taps, reamers, etc., will depend entirel
the capital one wishes to invest in special epuipment, but e
should be made to have an assortment that will include
the standard sizes employed in making automobile parts.
are fully considered in the following chapter.

Another form of bench grinder, provided with straight and an-ular rests and capable of driving two wheels, is shown at B. This s a slightly heavier form than shown at A, but is not sufficiently eavy to require the use of a special support. The grinder shown t C, is also intended to be mounted directly on the work bench nd in contrast to the other forms shown, which are dry grinders, t is provided with a housing and a small water tank for all forms f wet grinding. A very useful appliance for use with a bench rinder is shown in this illustration. This is an adjustable work est which can be set at any angle, making it especially valuable or tool grinding. The machine illustrated at D is a small two-wheeled grinder mounted on a substantial base which incorporates countershaft beneath the table. The grinders shown at A, B and C, make it necessary to install either a countershaft with tight and oose pulleys or a clutch pulley over them to drive. The grinder hown at D, with integral countershaft can be belted directly to he main drive shaft. A grinding machine for heavy work is shown t E. This is the same in general construction as the lighter forms, xcept that it is much more substantial. Attention is directed to the urfacing attachment mounted over the grinding wheel. This may e raised or lowered as desired, and as the table is accurately planed d surfaced it is very valuable for grinding work absolutely flat.

In many small shops it is not possible to furnish a very complete ortment of machine tools, and while tools designed for a specific urpose are always best if they can be purchased, it is sometimes sible to do very satisfactory work on simple machines adapted r a variety of work. A small bench machine that can be used ither as a lathe, drill press or milling machine is shown at Fig. 37. his may be driven by a small electric motor or can be provided ith a two-speed cone pulley, as shown. At A the machine is set p for use as a drill press, at B, the change of the attachment mits it to be employed for milling. Vertical feed is provided the milling cutter may be raised up or down, and both cross d lateral feeds of the work are obtained by hand lever. When d as a lathe it is possible to drive the lead screw through gear-so that an automatic lateral feed is obtained, this making pos-le thread cutting operations. The *flat table shown* at A, can

be supplemented by an index table for use in millin used as a sensitive drill the feed is by hand lever attach drill spindle. This tool, which is known as the "bench m is furnished complete with a countershaft milling vise, f dividing head and tool post. When used as a drill press, tl may be adjusted to any desired angle and the work b the tool if necessary. As a drill its capacity is up to a The spindle fits a number two standard, Morse taper shan

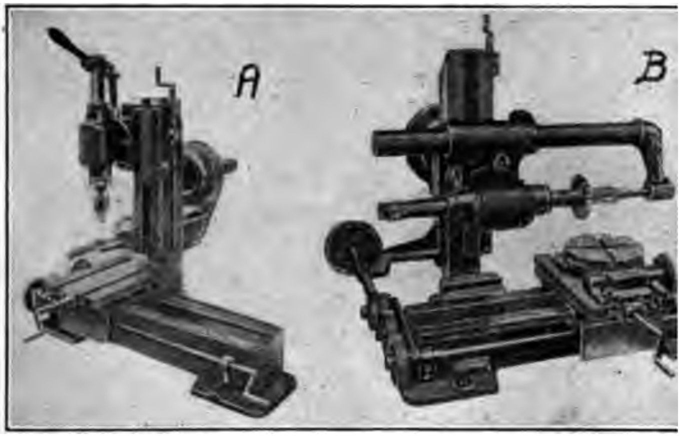


Fig. 37.—Combination Tool that Can be Used as a Lathe, Sensi or Milling Machine, Useful for the Small Repair Shop

used as a milling machine the open side design permits th to do work on long pieces such as cutting keyways, strai or Woodruff; squaring ends of long axle, splining and o of this nature. The diameter of the arbor is seven-eigh inch and the extension arm permits the use of an arb inches long. This machine will cut small spur gears gears. It will consume but one-fourth of a horsepowe used as a lathe, milling machine, or drill. While its c limited it can handle such a variety of work that it will a valuable item of equipment in even a machine shop pretensions.

s repairman who does not use power may find a number of machines turned by either hand or foot that will do very work. A foot power lathe suitable for light repair work en previously described. At Fig. 38, A, a hand-operated lrill and tool grinder is shown, while at B, a small hand which can be set up to form part of an ordinary vise is . The tool is carried by a reciprocating shaper-head worked andle, and the tool post may be raised or lowered vertically to any desired angle just as the larger shaper tool is. Screws ovided for both vertical and lateral feeds and a large variety k may be done. Such a hand shaper may be used for cutting ys, squaring shafts, repairing broken gears that have been by the autogenous process where solid metal has replaced ber of broken teeth, and for many other repairs that will sug-hemselves to a practical mechanic.

scellaneous Shop Equipment.—A number of useful articles air shop furniture are illustrated at Fig. 39. A and B are d plan views respectively of a substantial stand for working bile engines. The end pieces are cast iron leg members a semi-circular piece at the top. A boss is provided to it a through shaft upon which the motor carrying frame . When in the position shown at A, the motor is hung down, which provides ready access to the engine base. The carrying frame can be swung completely over until it is other side of the stand, under which conditions the cylin-nd parts at the top of the motor may be easily reached. licated by the dotted line, the motor carrying frame may at any intermediate point and firmly locked in place by g to the semi-circular pieces at the top of the end castings. ll be apparent from the view at B, the motor frame may igned so that the supporting members may be moved in to hold motors of various sizes. With this form of stand cessary to bolt it securely to the floor owing to the overhang motor.

t ingenious portable work-bench which has received applica-l a number of European repair shops is shown at C. This is lically different from the ordinary *work-bench* except that it

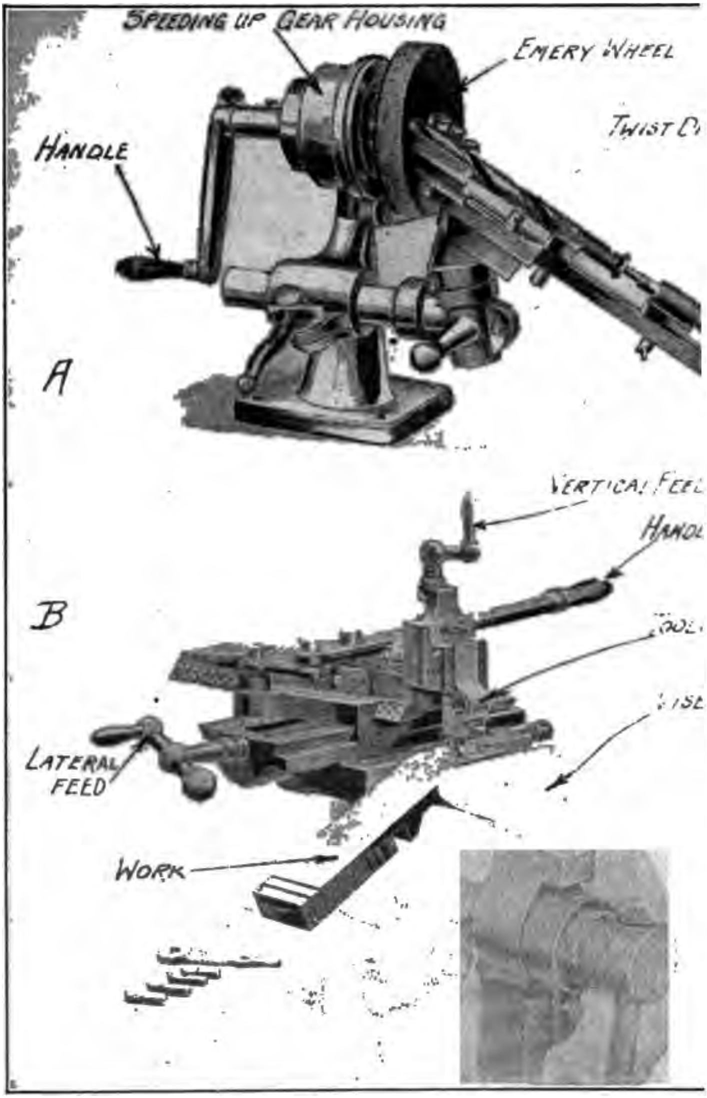
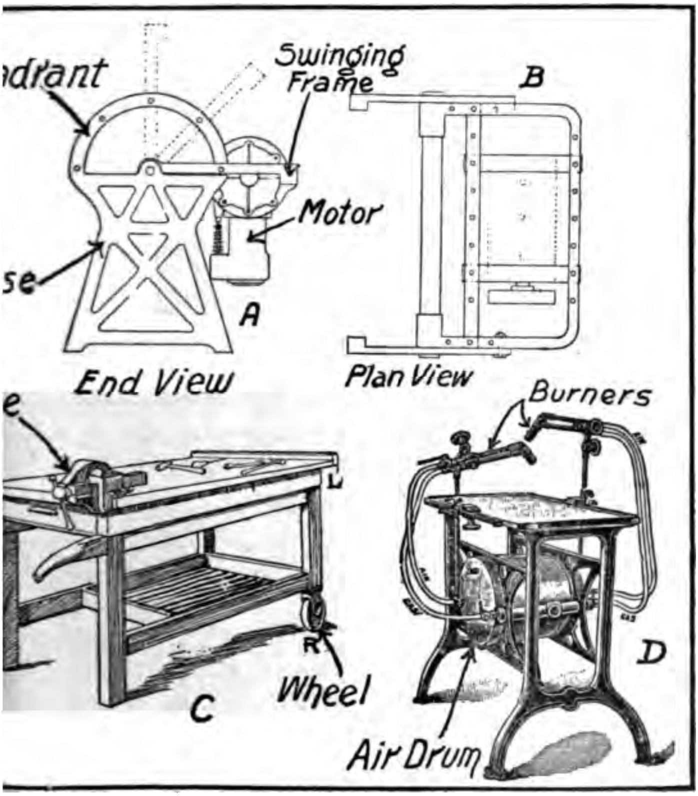


Fig. 38.—Hand Operated Tools of Value in the Small Shop

els under the legs at one end and a pair of barrow handles her end for moving it about. A vise is mounted at one cor- ıe bench, a box-like shelf underneath permits carrying parts to be worked on and drawers at the end of the table provide ıient carrying-place for tools. The bench is of strong con- ı and its steadiness is increased by having rollers under one heels only and mounting the vise and tool drawer so their s on the legs that have no wheels. A ledge may be placed three sides of the bench to prevent tools from sliding off is moved.



ıg. 39.—Repair Shop Furniture of Commendable Design.

Where city gas is available as fuel, the brazing stand ε practical article of repairshop furniture. This consists of a l iron table carrying an air receiver between the legs and fi support the brazing torches at any desired position above top. The top of the table is protected by fire brick, which are also used to form a furnace to concentrate the heat

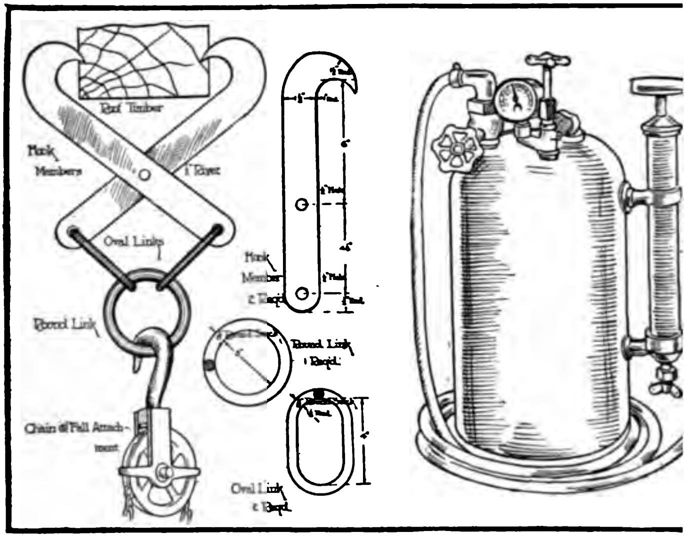


Fig. 40.—Outlining Construction of Supporting Member for Cl Attachment and Appliance for Cleaning Machine Parts Gasoline Spray.

pieces to be brazed. Complete instructions for use of this ı forms of brazing appliances to be described will be found iı dealing with miscellaneous processes.

The utility of the chain falls has been previously cc and it is somewhat a problem to provide a substantial n supporting these in shops where the overhead trolley is vided. The illustration at the left of Fig. 40 shows a veı and strong supporting fixture for chain falls or other h may be easily made by any repair shop mechanic in spare

:ts of the device are clearly shown and dimensions given, ' description is unnecessary.

; of the most disagreeable jobs incidental to repairing is g the accumulation of oil, road dust or grease from parts rorked on. The common method by means of a brush and e is wasteful and time-consuming, and it is not possible to ıte all corners thoroughly, as many of these are inaccessible. ıe or kerosene under pressure will remove dirt without using uantities of liquid. A typical cleaning outfit is shown at ht of Fig. 40. This consists of a large receiver fitted with a e gauge and with a shut-off valve to which a hose connecmade. The tank is filled about half full of the cleansing The hand pump provided is used to force air pressure into tainer in order to produce a spray of liquid having force to dislodge the particles of dirt. These are inexpensive ll save their cost in a short time by the saving in cleaning

ome large cities, notably New York, Chicago and Boston, ıas been considerable agitation on the part of the muniınd insurance authorities toward the enactment of legislaıking it compulsory for the automobile repair shop or garage :tor to install separators attached to the floor drains in order ent volatile inflammable oils, such as gasoline, kerosene and nts from flowing into the sewer. A device which has been d by the New York authorities is shown at Fig. 41. It t of boiler plate and standard pipe fittings and the prons can be easily ascertained by inspection of the illustration. or drain is connected to the main drum upper portion and ter from the floor must flow into that chamber before it ss into the sewer. As gasoline and lubricating oil are than water, they will float on the top of that liquid and will off through the vertical stand pipe extending from the n forming the top of the lower compartment to a point just he water line. The lower compartment is provided with a to show the height of liquid, a drain cock by which the ompartment may be emptied and a large cleanout plug for oval of sludge and *residue that will not* drain out through

the cock. A vent pipe extends from the lower compart the air in order to prevent the accumulation of any press to gas generation from vaporization of the volatile liquic

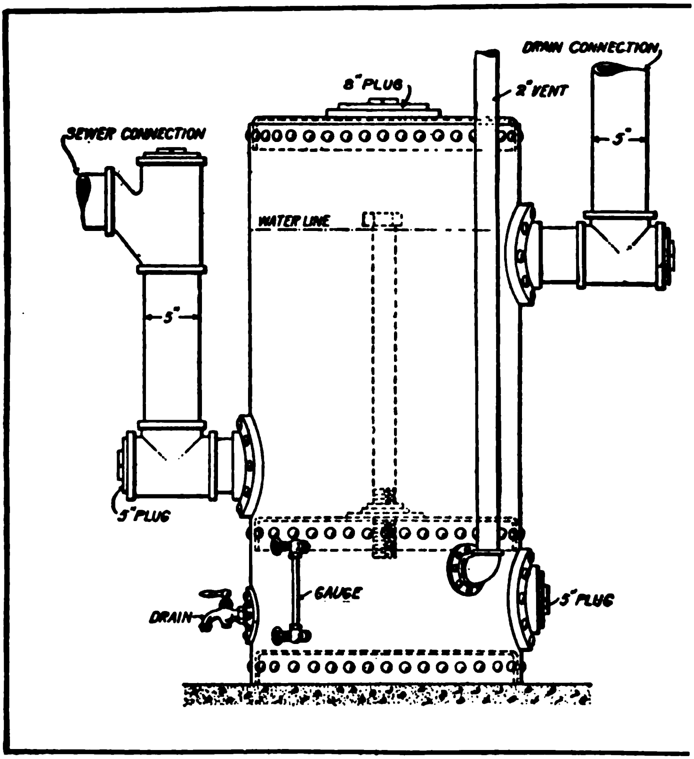
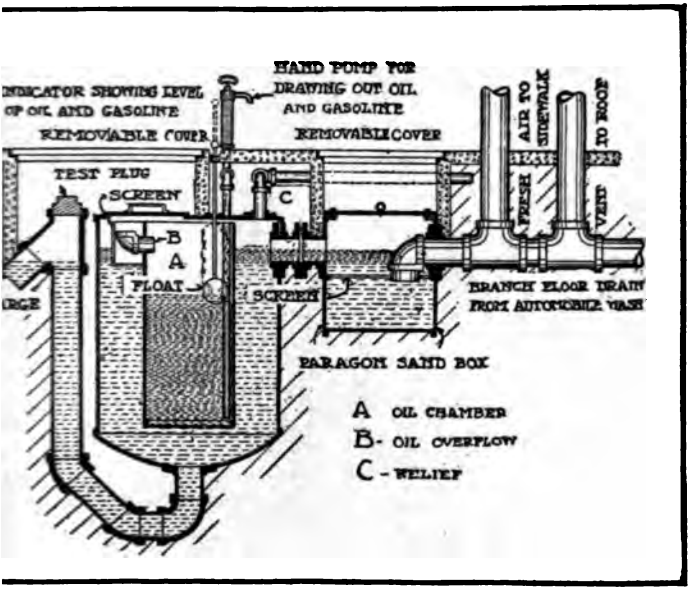


Fig. 41.—Separator Intended to Keep Volatile Inflammable Liqui Entering City Sewers.

upper portion of the container and the pipe connections provided with cleanout plugs.

Another form of separator is shown at Fig. 42. This is n to meet the requirements of the fire and building departr New York City and is known as the Paragon Separatoi *said that* the best position for this device is near the side w

ie floor with a hand pump projecting through the floor. te water containing gasoline and oil enters the branch floor d flows into a sand box where all solid matter is extracted. is point the liquid flows through a screen into a U-shaped r and then out through a discharge pipe into the street Inside the main portion of the U-shaped container is the al oil chamber in which the volatile liquids are collected.



—Another Form of Separator for Garage or Repair Shop Use.

e stated, these are lighter than water and will float on the ınd thus enter the oil chamber through a suitable opening ıck of the cylinder. An indicator with a ball float shows of liquid in the oil chamber and when a sufficient quantity ted it may be drawn out by a hand pump. Two air vents ided, one running to the roof for taking out the impure air, other one runs to the sidewalk to let in fresh air which is han that saturated with *hydrocarbon vapor,* thus driving it

out. The sand box is placed in a convenient position so t
ready access when new filtering material is needed. Reli
are provided in both the U-shaped container and in the oil
to prevent the accumulation of any pressure in either of tl
tions of the separator.

Air Compressor Types.—All up-to-date repair shops, e

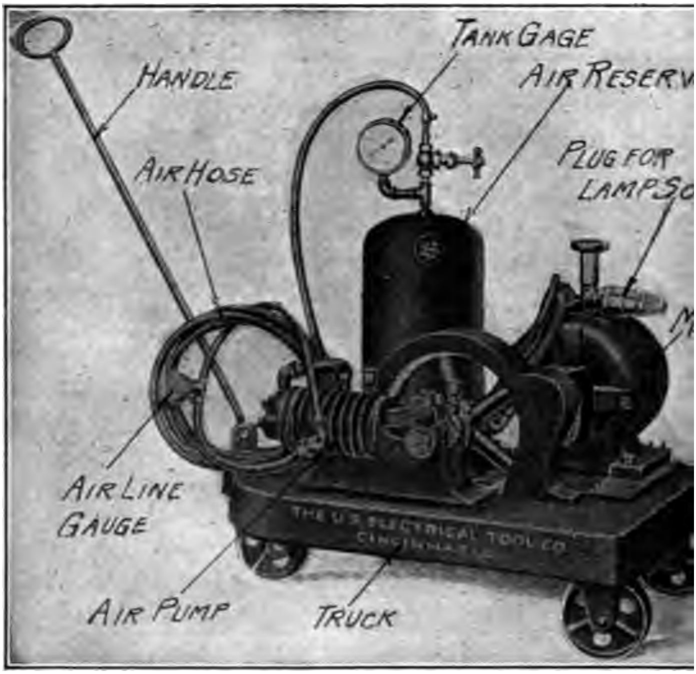


Fig. 43.—Portable Electrically Operated Air Compressor O

if they are an adjunct to a garage, or if they cater to tir
work, have some power-driven source of compressed air. A
air has many uses besides that of filling pneumatic tires, a
be used for blowing out loose carbon particles from the com
chamber or light chips and steel fragments from gear boxes
axle housings. The air blast may also be used for coolin
steel gradually when annealing it and can also be empl

pipe joints, fuel containers, etc. The illustration at Fig. 43 . portable, electrically driven power pump suitable for public ate garages and repair shops. It is simple and compact in ıction and as it is mounted on a wheeled base it can be easily around the building or outside to the curb. A tank, 12 inches nd 6 inches in diameter, into which the pump discharges, ıts condensation and oil from entering and injuring the tire.

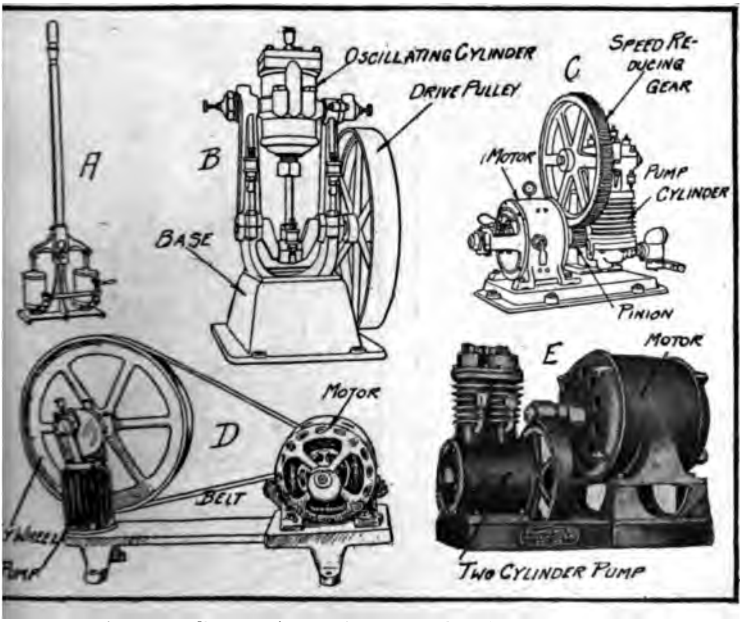


Fig. 44.—Conventional Forms of Air Compressors.

s said that the pumping action is very rapid, as a 35 x 4 inch can be pumped from flat to 70 pounds pressure in one and one-'minutes. The motor is a Westinghouse, one and a quarter horse-er capacity, designed to operate from the lighting circuit and ' be secured in any of the voltages commonly used.

A group of air compressors of different designs is shown at Fig. That at *A*, *is a powerful, hand operated* double pump suitable *hose garages and repair shops not* provided with mechanical

power. It is operated through a lever which is sufficiently
it can be worked by one or two men standing upright. T
at B is a substantial power-driven compressor of large
having an oscillating cylinder. This type is used only i
repair shops where it is necessary to use a large air tank whi

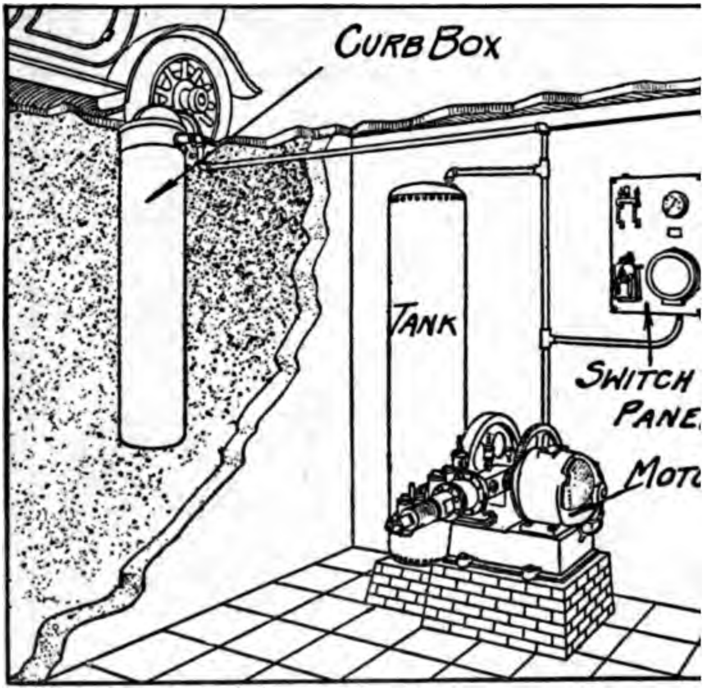


Fig. 45.—Sectional View Showing Hale Curb Box Installed witl matic Air Compressor and Storage Tank.

be constantly filled. The air pump at C, has a vertical
and is driven from an electric motor by means of a spur pi
the armature shaft which meshes with a large gear on th
crankshaft. This is attached to a substantial iron base
intended to be bolted to the floor. A small portable powe
for use on the bench is shown at Fig. 44, D. This also is

an electric motor, the power being transmitted from the arma-e by belt connection to the rim of a large flywheel-pulley attached the crank disc of the pump. The outfit at E is similar in opera-n to that shown at C, except that a two cylinder air compressor used. This is practically the same in general construction as e other forms illustrated, except that the use of two cylinders akes for a more steady flow of air.

A complete air compressor outfit provided with automatic regu-ting means and an apparatus to distribute air at the curb is shown ; Fig. 45. This enables automobile owners to secure a supply of ir without having to drive the car into the garage or dragging portable air compressor outfit across the sidewalks. The accom-anying diagram clearly shows the arrangement of this outfit. A ank is buried in the ground and this connects with the compressor utfit located in the basement. The lid of the curb box is flush rith the sidewalk and in a few inches from the curb. The user aises the lid, takes out the hose and when the operation of tire nflation is complete, the hose returns to the box automatically when it is released. The air compressor installation consists of a eservoir or tank in the basement, an air compressor driven by an lectric motor and a control panel. When the air pressure in the ank reaches a certain predetermined amount, an automatic switch reaks the circuit and the motor ceases to drive the pump. As oon as the pressure falls below the minimum allowable, the auto-atic switch again functions to close the circuit and start the pump oing. In addition to the pipe leading to the curb box a branch ipe may be run to the garage interior and to the repair shop as rell.

Liquid Fuel Storage.—The problem of liquid fuel storage is n important one for garages or repair shops, especially in cities here the municipal regulations pertaining to the storage of vola-le hydrocarbons are severe. If the fuel is to be used only r shop purposes, either of the fuel storage systems shown at g. 46, A and B, will prove practical. That at A is the hy-aulic system in which the gasoline stored in an underground k is forced out *by displacement,* water flowing into the tank *the city main. The outfit at B* also includes an under

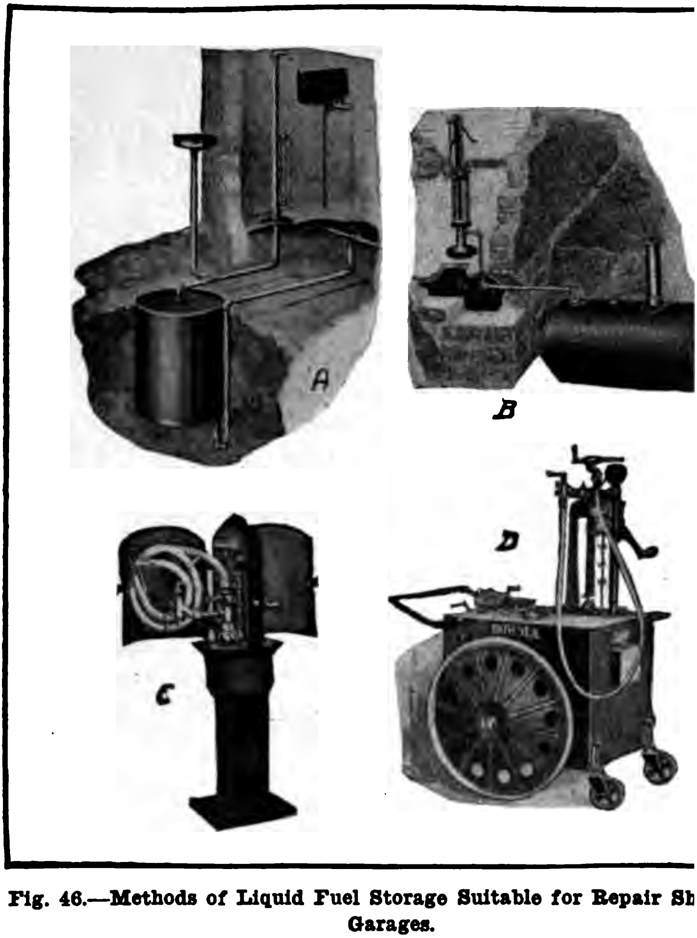
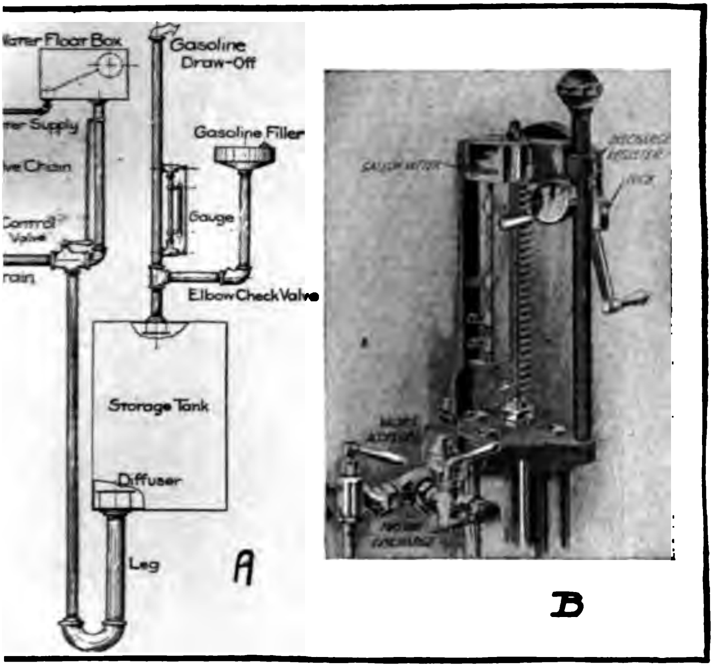


Fig. 46.—Methods of Liquid Fuel Storage Suitable for Repair Sh Garages.

ground tank which is placed outside of the walls of th ing, but the gasoline is drawn from the tank by a pump. Where gasoline is sold to passing motorists two ap that will promote quick service are shown at Fig. 46, C, That at C, is a box designed to be placed outside of the g repair shop near the door or driveway so that cars do not run into the garage to be filled. This serves merely to

ıuring pump drawing fuel from an underground tank and 'hich will extend from the pump to the fuel container of r. The outfit shown at D, consists of a rectangular tank ·d on wheels and having the usual form of measuring pump. ınk will hold several barrels of fuel, can be moved easily



7.—Outlining Two Practical Methods of Raising Liquid Fuel from Underground Tanks.

lace to place and the measuring pump insures that the liquid dispensed in proper quantities and without waste.

principle of action of the hydraulic fuel supply system is at Fig. 47, A. The various parts comprising the assembly ırly outlined. When it is desired to draw out gasoline it is necessary to open the water control valve which permits o flow into the tank to displace the fuel. At Fig. 47, B, the

usual form of automatic measuring pump is shown. This is vided with a series of stops, so quantities varying from one pi one gallon may be pumped by limiting the stroke of the p A two-way discharge is provided, one for filling cans, the othe attaching a supply hose to reach to the car tank. A meter is

Fig. 48.—Showing Forge Equipment Suitable for Automobile R Shops.

that will indicate every gallon pumped. The pump plung actuated by a spur rack which is operated by a pinion tı by a hand crank. But little force is needed to operate this ı owing to the large leverage provided by the hand crank an small pitch radius of the pinion.

plete Forge Equipment Desirable.—Quite a number of re-s involve blacksmithing or brazing processes and two dis-·ges should be installed. The usual equipment is a steel f medium size, with a power-driven rotary blower, ·ed for forging and welding. For brazing, melting bab-al, hardening and tempering, annealing, and heating sol-rons a gas forge should be used, this taking its air from

—Complete Blacksmithing Outfit of Value in Small Repair Shop Equipment.

of the air compressor outfit, and its gas from the city or ins. In the smaller towns and villages the portable gasoline forge can be used to advantage, providing that coal or s is not available. In the accompanying illustration, Fig. nple and practical forge outfit is shown, this including and coal burning types. Between the coal and gas forge, pench is usually erected, this having a strong vise and a awer. This bench can be used in both brazing and solder-esses, and the drawer can be divided into two compartments, old the blacksmith tools, the other the soldering irons and tal tools. The vise is handy to the workman at either forge. ining equipment is simple, a medium sized anvil, heavy

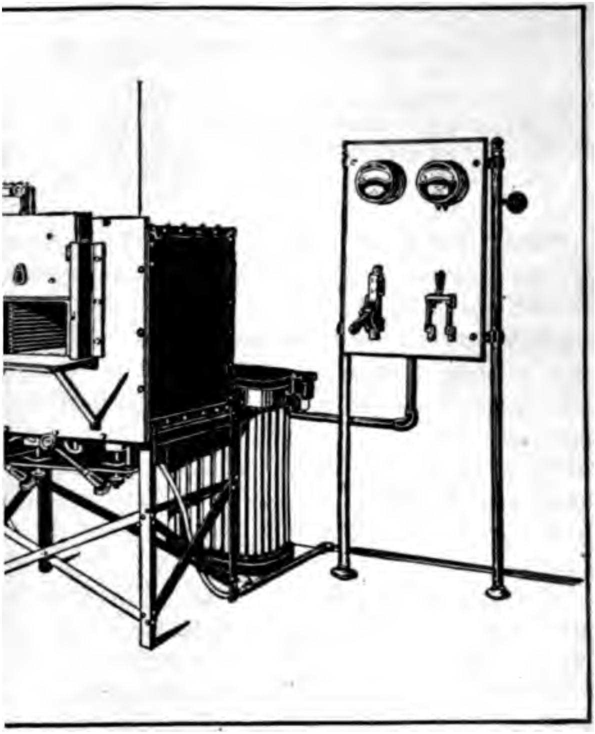
and medium sledge hammers, three or four forge hammers, for holding round, flat and irregular work, cutting off to "hardies" for both cold and hot cutting and the flattin swaging tools with handles of conventional patterns.

The gas forge shown is made of standard pipe and fi the table is a framework of iron pipe, across the top of a piece of sheet steel serves to support ordinary firebrick a which the flame may be directed. A small hand torch is pro this for use on the smaller brazing or soldering jobs. The m ladles can be placed over either coal or gas flame, and either will melt the anti-friction metals used in lining bearing bo

The parts of a blacksmith's equipment for repair work may be purchased as a complete outfit for around $50.00 are at Fig. 49. While two or three of the tools are intended for horseshoeing they can be employed to equally good advant the automobile repair shop. These consist of the farrier's mer, knife and pincers. The remaining tools will be found able for use in general metal work. A post drill is pr which is a very practical tool for shops not provided with An outfit of drills in standard sizes is usually supplied wit tool. The forge is light and compact and a hand-operated b is utilized to furnish the blast. A post vise, medium size hand sledge and various small tools complete this set. In a already furnished with various machine tools the only parts outfit needed would be the forge, anvil and post vise. Tong be made as needed to best suit the requirements of the wo hand.

In large repair shops, where considerable tool dressing is and where it is necessary to heat-treat various parts, the el furnace shown at Fig. 50 will prove a good investment. amount of heat may be regulated within close limits and ciently high temperatures may be obtained for hardening, burizing or annealing any pieces within the range of the fu While it is not expected that a furnace of this type will be in the small or medium size shops, there is sufficient work i large establishments or service stations to warrant the install of a furnace of this nature, if electric current is available,

›r oil-burning type where it is not convenient to ly heated form. The almost universal use of high in the construction of automobiles makes it neces- ıirman to have some knowledge of heat treatment ›ecial steels. They cannot be machined unless an-



:trically Heated Furnace for Heat Treating Steel.

ıf but little more value than ordinary machinery y are not properly heat-treated to bring out the ristics desired after fabrication. A review of the .ting processes, especially those needed for the ›els used in automobile construction, will be found aling with miscellaneous processes.

CHAPTER II.

SMALL TOOL EQUIPMENT FOR REPAIR SHOPS

Tools for Adjusting and Erecting—Drilling Machines—Machine Accessories —Measuring Tools—Lathe Accessories and Lathe Tools—Miscellaneous Tools—Special Tools to Facilitate Repair Work—Wheel and Gear Pullers —List of Tools and Supplies for Typical Shop.

THERE are so many small items of equipment entering into the outfit necessary to carry on repair work economically and efficiently, and so many supplies are needed that it is difficult to distinguish between the tools used only on the car and others which serve a general purpose about the garage or repair shop. In the previous chapter the various forms of machine tools that have a place in the machine room equipment have been described, so in this chapter endeavor will be made to confine the discussion to the smaller tools used in assembling and dismantling automobiles as well as in making the necessary adjustments to the various machine parts.

Machine tools in themselves are of little value without an adequate supply of smaller tools to be used in connection with them. For example, a lathe could not be employed to advantage without a complete set of accessories and cutting tools, while a drilling machine would be valueless if not supplied with proper chucks and drills for making the holes. We will first consider the small tool equipment, such as would be used by automobilists or repairmen in making the everyday adjustments on the car, then the tools that are of special value to the machinist and lastly those special appliances which facilitate repair work and which usually can be made cheaper than they can be purchased.

Tools for Adjusting and Erecting.—A very complete outfit of small tools, some of which are furnished as part of the tool

l
p
ul
n
t
e
r
t

ment of various cars are shown in group at Fig. 51. This group includes all of the tools necessary to complete a very practical kit and it is not unusual for the floor man who is continually dismantling and erecting cars to possess even a larger assortment than indicated. The small bench vise provided is a useful auxiliary that can be clamped to the running board of the car and should have jaws at least three inches wide and capable of opening four or five inches. It is especially useful in that it will save trips to the bench vises and can also be carried as part of the tool equipment by the motorist to advantage, as it has adequate capacity to handle practically any of the small parts that need to be worked on when making repairs. A blow torch, tinner's snips and soldering copper are very useful in sheet metal work and in making any repairs requiring the use of solder. The torch can be used in any operation requiring a source of heat. The large box wrench shown under the vise is used for removing the wheel hub cap and sometimes has one end of the proper size to fit the valve chamber cap. The piston ring removers are easily made from thin strips of sheet metal securely brazed or soldered to a light wire handle. These are used in sets of three for removing and applying piston rings in a manner to be indicated in the next chapter. The uses of the wrenches, screw drivers, and pliers shown are known to all and the variety outlined should be sufficient for all ordinary work of restoration. The wrench equipment is very complete including a set of open end S-wrenches to fit all standard bolts, a spanner wrench, socket or box wrenches for bolts that are inaccessible with the ordinary type, adjustable end wrenches, a thin monkey wrench of medium size, a bicycle wrench for handling small nuts and bolts, a Stillson wrench for pipe and a large adjustable monkey wrench for the stubborn fastenings of large size.

Three different types of pliers are shown, one being a parallel jaw type with size cutting attachment, while the other illustrated near it is a combination parallel jaw type adapted for use on round work as well as in handling flat stock. The most popular form of pliers is the combination pattern shown beneath the socket wrench set. This is made of substantial drop forgings having a hinged joint that can be set so that a very wide opening at the

jaws is possible. These can be used on round work and for w
cutting as well as for handling flat work.

A very complete set of files, including square, half rou

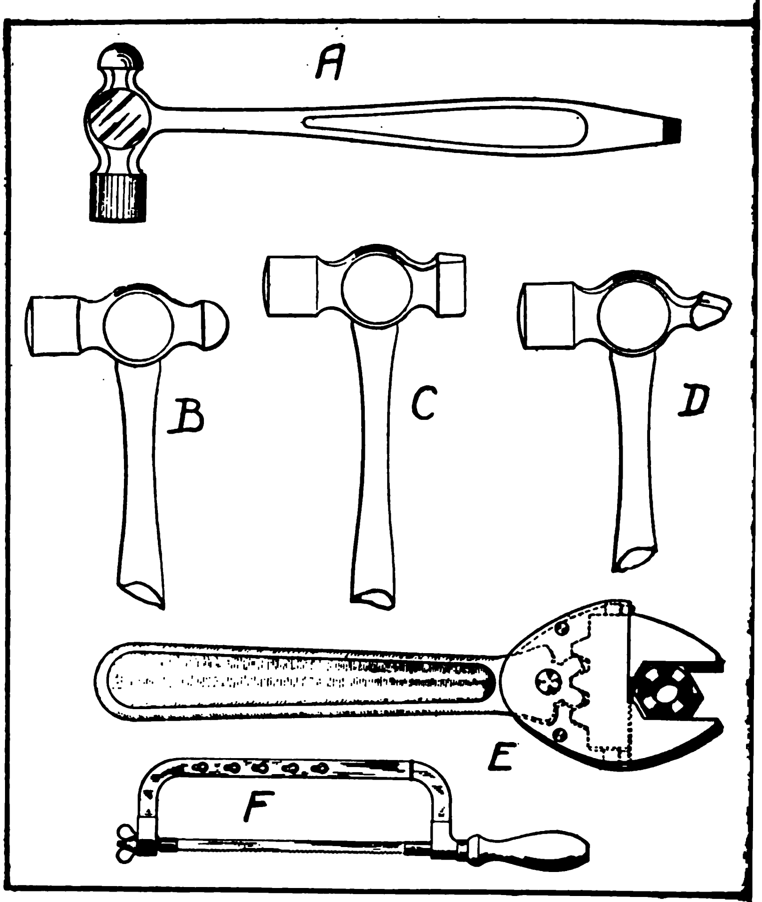


Fig. 52.—Forms of Hammers Suitable for the Automobile Repairm Tool Kit.

mill, flat bastard, three-cornered and rat tail are also necess
A hacksaw frame and a number of saws, some with fine teeth
tubing and others with coarser teeth for bar or solid stock.

ound almost indispensable. A complete punch and chisel set ld be provided, samples of which are shown in the group e the complete outfit is outlined in another illustration. A ber of different forms and sizes of chisels are necessary, as one is not suitable for all classes of work. The adjustable end iches can be used in many places where a monkey wrench iot be fitted and where it will be difficult to use a wrench ng a fixed opening. The Stillson pipe wrench is useful in ing studs, round rods, and pipes that cannot be turned by other means. A complete shop kit must necessarily include ous sizes of Stillson and monkey wrenches, as no one size can xpected to handle the wide range of work the repairman must with. Three sizes of each form of wrench can be used, one, a ch, is as small as is needed while a 12 inch tool will handle st any piece of pipe or nut used in a motor car. For large k a 16 inch or 18 inch Stillson will be found of value.

Two or three sizes of hammers should be provided, according ndividual requirement, these being small riveting, medium and yweight machinist's hammers. A very practical tool of this na- for the repair shop is shown at Fig. 52, A, as it can be used hammer, screw driver or tire iron. It is known as the artan" hammer and is a tool steel drop forging in one piece ing the working surfaces properly hardened and tempered while metal is distributed so as to give a good balance to the head a comfortable grip to the handle. The hammer head provides a tive and comfortable T-handle when the tool is used as a screw rer or tire iron. Machinist's hammers are provided with three es of heads, these being of various weights. That at B, is the n most commonly used and is termed the "ball pein" on ac- nt of the shape of the portion used for riveting. The straight shown at C, is just the same as the cross pein shown at D, pt that in the latter the straight portion is at right angles to hammer handle, while in the former it is parallel to that aber.

A self-adjusting monkey wrench which is known as the "speed " is shown at Fig. 52, E. The act of pulling on the handle tens the wrench on the nut by means of a rack which is formed

integral with the movable jaw and a portion of a pinion mesh with it at the end of the handle. Pulling on the handle tight the wrench on the nut and the harder one pulls, the more secur the nut is gripped. As moving the handle in the opposite direct spreads the jaws apart, a sort of a ratchet action is possible if

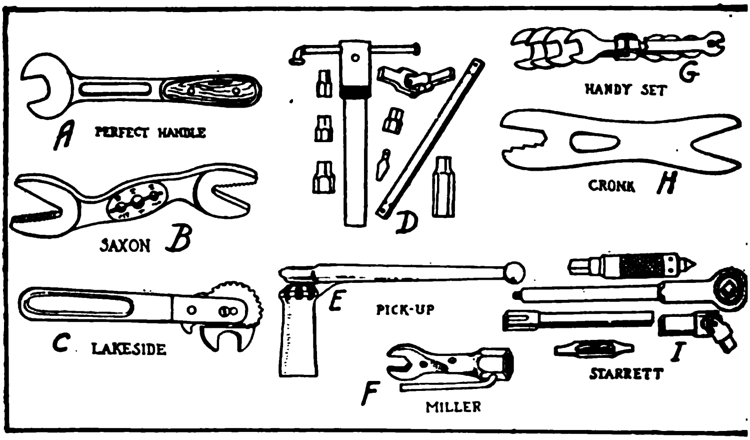


Fig. 53.—Wrenches are Offered in Many Forms.

handle is alternately pulled and pushed, rendering it unnecess to take the wrench off and secure a new hold on the nut or b head for each turn. The wrench is composed of only three pi and the smallest size will fit nuts varying from $\frac{1}{4}$-inch to $\frac{3}{4}$-in In order to unscrew a nut it is necessary to turn the wrench o so the handle will be pulled in the opposite direction to that u in screwing the nut down. This insures a secure grip in eit case and permits of a ratchet motion without setting any trip pawl. The hacksaw frame shown at Fig. 51, is a solid type adapt only to take one length of blade. As hacksaw blades are made varying lengths it may be possible that a longer one than that fra was made for would be the only thing available. In such a c the adjustable hacksaw frame shown at Fig. 52, F, would pen of using a longer saw blade by merely extending the frame far as is necessary.

Wrenches have been made in infinite variety and there are a score or more patterns of different types of adjustable socket and off-set wrenches. The various wrench types that differ from the more conventional monkey wrenches or those of the Stillson pattern are shown at Fig. 53. The "perfect handle" is a drop forged open end form provided with a wooden handle similar to that used on a monkey wrench in order to provide a better grip for the hand. The "Saxon" wrench is a double alligator form, so called because the jaws are in the form of a V-groove having one size of the V plain, while the other is serrated in order to secure a tight grip on round objects. In the form shown, two jaws of varying sizes are provided, one for large work, the other to handle the smaller rods. One of the novel features in connection with this wrench is the provision of a triple die block in the centre of the handle which is provided with three most commonly used of the standard threads including 5/16-inch-18, 3/8-inch-16, and 1/2-inch-13. This is useful in cleaning up burred threads on bolts before they are replaced, as burring is unavoidable if it has been necessary to drive them out with a hammer. The "Lakeside" wrench has an adjustable pawl engaging with one of a series of notches by which the opening may be held in any desired position.

Ever since the socket wrench was invented it has been a popular form because it can be used in many places where the ordinary open end or monkey wrench cannot be applied owing to lack of room for the head of the wrench. A typical set which has been made to fit in a very small space is shown at D. It consists of a handle, which is nickel plated and highly polished, a long extension bar, a universal joint and a number of case hardened cold drawn steel sockets to fit all commonly used standard nuts and bolt heads. Two screw driver bits, one small and the other large to fit the handle and a long socket to fit spark plugs are also included in this outfit. The universal joint permits one to remove nuts in a position that would be inaccessible to any other form of wrench, as it enables the socket to be turned even if the handle is at one side of an intervening obstruction.

The "Pick-up" wrench shown at E, is used for spark plugs and the upper end of the socket is provided with a series of grooves

into which a suitable blade carried by the handle can be dropp The handle is pivoted to the top of the socket in such a way th the blades may be picked up out of the grooves by lifting on t end of the handle and dropped in again when the handle is swu around to the proper point to get another hold on the socket. T "Miller" wrench shown at F, is a combination socket and op end type, made especially for use with spark plugs. Both t open end and the socket are the same size and either may l used as is the most convenient. The "Handy" set shown at G, co sists of a number of thin stamped wrenches of steel held togeth in a group by a simple clamp fitting, which enables either end any one of the four double wrenches to be brought into play a cording to the size of the nut to be turned. The "Cronk" wren shown at H, is a simple stamping having an alligator opening one end and a stepped opening capable of handling four differe sizes of standard nuts or bolt heads at the other. Such wrench are very cheap and are worth many times their small cost, especial for fitting nuts where there is not sufficient room to admit t more conventional pattern. The "Starrett" wrench set, which shown at I, consists of a ratchet handle together with an extensi bar and universal joint, a spark plug socket, a drilling attachme which takes standard square shank drills from 1/8-inch to 1/2-in in diameter, a double ended screw driver bit and several adju ments to go with the drilling attachment. Twenty-eight assort cold drawn steel sockets similar in design to those shown at D, fit all standard sizes of square and hexagonal headed nuts are a included. The reversible ratchet handle, which may be slipp over the extension bar or the universal joint and which is a adapted to take the squared end of any one of the sockets is ceptionally useful in permitting, as it does, the instant release pressure when it is desired to swing the handle back to get anot hold on the nut. The socket wrench sets are usually supplied hard wood cases or in leather bags so that they may be kept togeth and protected against loss or damage. With a properly select socket wrench set, either of the ratchet handle or T-handle fo any nut on the car may be reached and end wrenches will not necessary.

ion has been previously made of the importance of provid-
mplete set of files and suitable handles. These should be
us grades or degrees of fineness and three of each kind
e provided. In the flat and half round files three grades

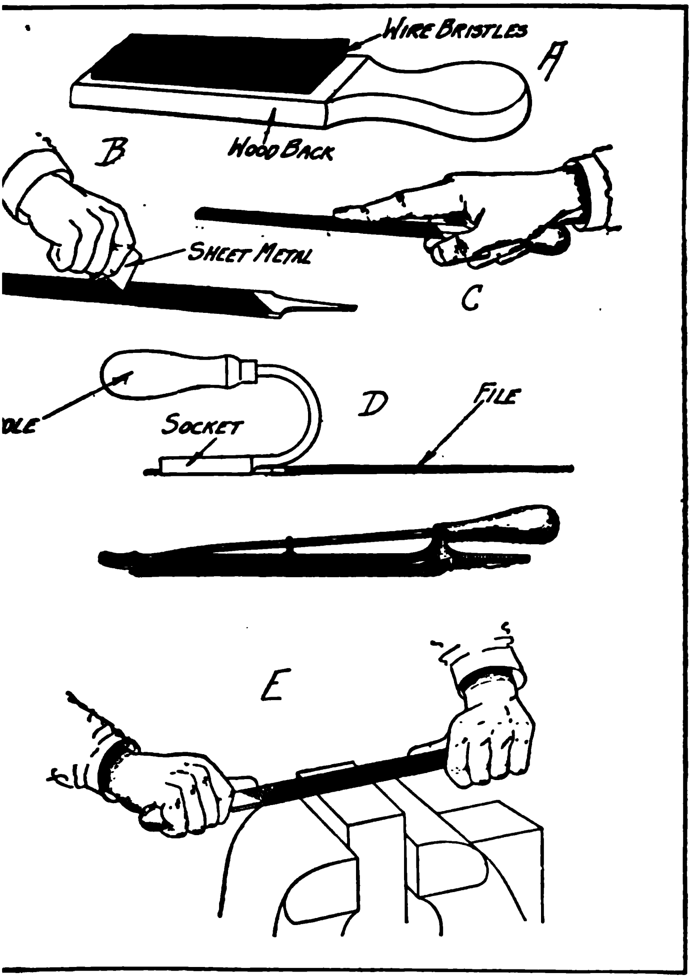


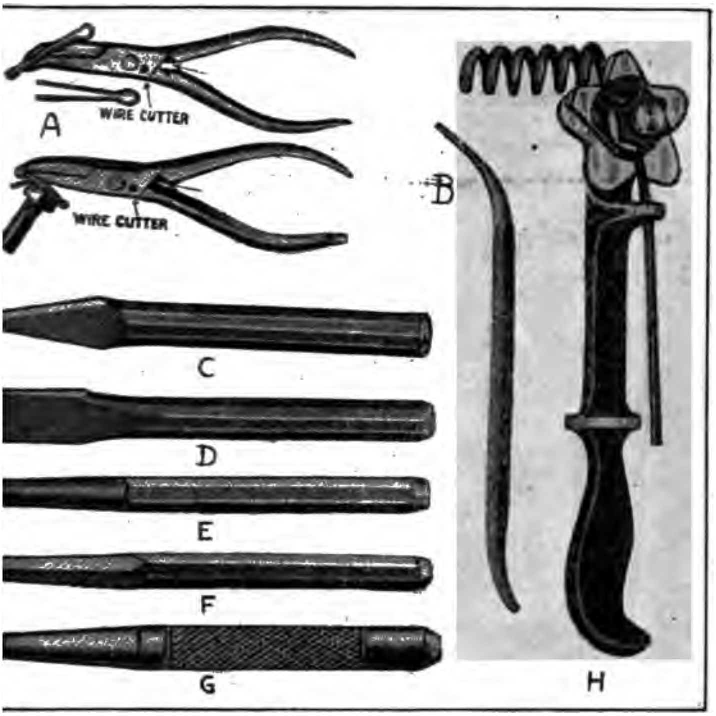
Fig. 54.—Illustrating Use and Care of Files.

are necessary, one with coarse teeth for roughing, and others medium and fine teeth for the finishing cuts. The round or tail file is necessary in filing out small holes, the half round finishing the interior of large ones. Half round files are well adapted for finishing surfaces of peculiar contour, such as inside of bearing boxes, connecting rod and main bearing caps, Square files are useful in finishing keyways or cleaning out bu splines, while the triangular section or three-cornered file i value in cleaning out burred threads and sharp corners. Flat are used on all plane surfaces.

The file brush shown at 54, A, consists of a large number of bristles attached to a substantial wood back having a handl convenient form so that the bristles may be drawn through interstices between the teeth of the file to remove dirt and gr If the teeth are filled with pieces of soft metal, such as solde babbitt, it may be necessary to remove this accumulation wi piece of sheet metal as indicated at Fig. 54, B. The metho holding a file for working on plain surfaces when it is fitted the regular form of wooden handle is shown at C, while two t of handles enabling the mechanic to use the flat file on plain faces of such size that the handle type indicated at C, could be used on account of interfering with the surface finished shown at D. The method of using a file when surfaces are fini by draw filing is shown at E. This differs from the usual me of filing and is only used when surfaces are to be polished and little metal removed.

One of the most widely used of the locking means to pre nuts or bolts from becoming loose is the simple split pin, somet called a "cotter pin." These can be handled very easily if the cial pliers shown at Fig. 55, A, are used. These have a curved that permits of grasping the pin firmly and inserting it in the ready to receive it. It is not easy to insert these split pins by o means because the ends are usually spread out and it is har enter the pin in the hole. With the cotter pin pliers the ends be brought close together and as the plier jaws are small the may be easily pushed in place. Another use of this plier, *indicated,* is to bend over the ends of the split pin in orde

: it from falling out. To remove these pins a simple curved :s shown at Fig. 55, B, is used. This has one end tapering ›int and is intended to be inserted in the eye of the cotter e purchase offered by the handle permitting of ready re-



i.—Outlining Use of Cotter Pin Pliers, Spring Winder and Showing Practical Outfit of Chisels.

of the pin after the ends have been closed by the cotter pin

omplete chisel set suitable for repair shop use is also shown 55. The type at C, is known as a "cape" chisel and has ›w cutting point and is intended to chip keyways, remove ›ut of corners and for all other work where the broad cut-ge chisel, shown at D, *cannot be used.* The form with the

wide cutting edge is used in chipping, cutting sheet metal, e At E, a round nose chisel used in making oil ways is outlined, wh a similar tool having a pointed cutting edge and often used for t same purpose is shown at F. The centre punch depicted at G, very useful for marking parts either for identification or for dri ing. In addition to the chisels shown, a number of solid punch or drifts resembling very much that shown at E, except that t point is blunt should be provided to drive out taper pins, bolt rivets, and other fastenings of this nature. These should be pr

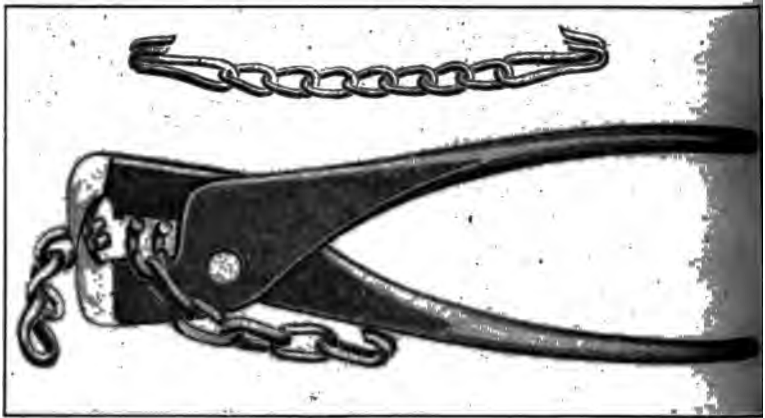


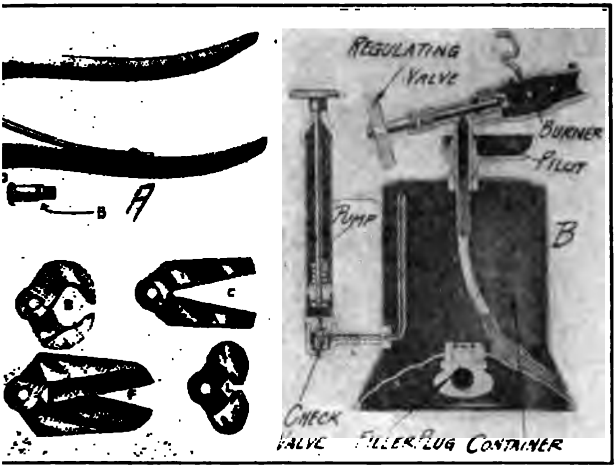
Fig. 56.—Special Pliers for Use in Repairing Weed Tire Chains.

vided in the common sizes. A complete set of real value would sta at 1/8-inch and increase by increments of 1/32-inch up to ½-inc A simple spring winder is shown at Fig. 55, H, this making i possible for the repairman to wind coil springs, either on the lat or in the vise. It will handle a number of different sizes of wire an can be set to space the coils as desired.

Anti-skid chains form an important item in the equipment the car and as they are subject to wear it is desirable to replace th worn cross chains with new ones from time to time, as some of the wear out quicker than others. A special pair of pliers havin *overlapping* ends as shown at Fig. 56, is intended to assist in

pplying the cross chains. In order to remove the ked link at each end is spread apart by the wedging lier jaws which make it possible to remove the cross ıe side links. When a cross chain is to be applied k is placed near the fulcrum or hinge pin and the ent down over the side chain by compressing the plier

mobile repairman was to provide himself with every



eft, Useful Combination Pliers Having a Series of Inter- Heads; at Right, Sectional View Outlining Construction › Blow Torch.

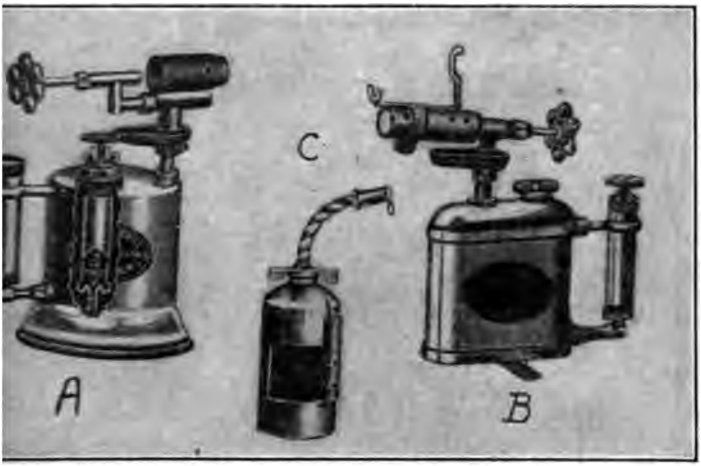
that could be used to advantage, the investment in ould be large. This has resulted in the development angeable tool consisting of one standard pair of ·ill take a large variety of pliers, pincers and shears f readily detachable heads which will fit the same :hange is readily made and a number of useful tools ıut requiring a large investment. Samples of some pular heads are shown at Fig. 56, below the handle. a leather or paper *punch and may* be obtained also

for punching metal. B, is a pincer head adapted for heavy w
The head at C, is an alligator form which can be adapted to a
range of sizes. At D, a combination plier head is outlined,
consisting of flat nose, cutting and gas pipe pliers. At F, is sho
pair of tinner's snip blades to fit the handle. The head L, is
for working on Weed tire chains.

The tool is easily taken apart, the operation consisting of
moving the wing nut C, from the centre bolt, lifting off the top
of the handle and then setting any desired head in the rece
each handle so the shank of the head is flush with the face o
handle. The square shank B, on the bolt is entered into the
hole A, in the top handle. After the two parts are togeth
wing nut C, is screwed down as tightly as possible. Th
which holds the handles together, turns in the lower hal
cannot fall out. The object of this is to permit the lower
the handle to turn on the bolt because on account of the
shank on the bolt and the square hole in the upper half
handle, the bolt itself turns with this half, thereby prev
any possibility of the wing nut becoming loose in operation.
interchangeable tool is supplied in a neat box, having a pla
the handle and the various heads supplied with it.

Mention has bean previously made of the utility of the
line blow torch. A typical torch is shown in section at Fig.
in order that the internal construction may be readily under
It consists of a main container of heavy sheet metal to whic
air pump is attached at one side to act as a handle. The l
portion of this pump communicates with the interior of the
by means of a bent pipe which deflects the air to the top o
fuel receptacle. The upper portion of the tank is supplied w
burner having a pipe leading to the bottom. A filling plug i
serted at the bottom of a conical depression which acts
funnel when the torch is inverted for filling. The function o
air pump is to force air into the tank and displace the liquid
forcing it to the burner where it is vaporized. The burner
the Bunsen pattern and gives a blue flame. The intensi
the flame is regulated by a needle valve. In order to sta
torch it is necessary to fill the pilot cup under burner with

d to ignite same, letting it burn until the torch burner
ı sufficiently heated to vaporize the liquid fuel. Three
f these blow pipes are shown at Fig. 58. That at A, has
ı set into the tank and a more powerful burner that will
ery hot flame for brazing. The torch at B, has a flat fuel
tead of the usual cylindrical form and has the filler opening
p instead of at the bottom. The flat torch is easier to carry
e round ones because it occupies less space. A very small



—Practical Gasoline Blow Torches for Automobile Repair Work.

hich needs no air pressure is shown at C. Sufficient heat
rize the fuel and to start the torch may be obtained by
a match at the curved portion of the burner. This form
t produce the intense heat that the torches having internal
sure do, but the flame is of sufficient intensity to heat a
g iron, or perform any of the work incidental to soldering.
ling Machines.—Drilling machines may be of two kinds,
power operated. For drilling small holes in metal it is
y to run the drill fast, therefore the drill chuck is usually
by gearing in order to produce high drill speed without
the handle too fast. A *small hand drill* is shown at Fig.

59, A. As will be observed, the chuck spindle is driven by a s
bevel pinion, which in turn, is operated by a large bevel gear tu
by a crank. The gear ratio is such that one turn of the ha
will turn the chuck five or six revolutions. A drill of this de
is not suited for drills any larger than one-quarter inch. Fo
with drills ranging from one-eighth to three-eighths, or even

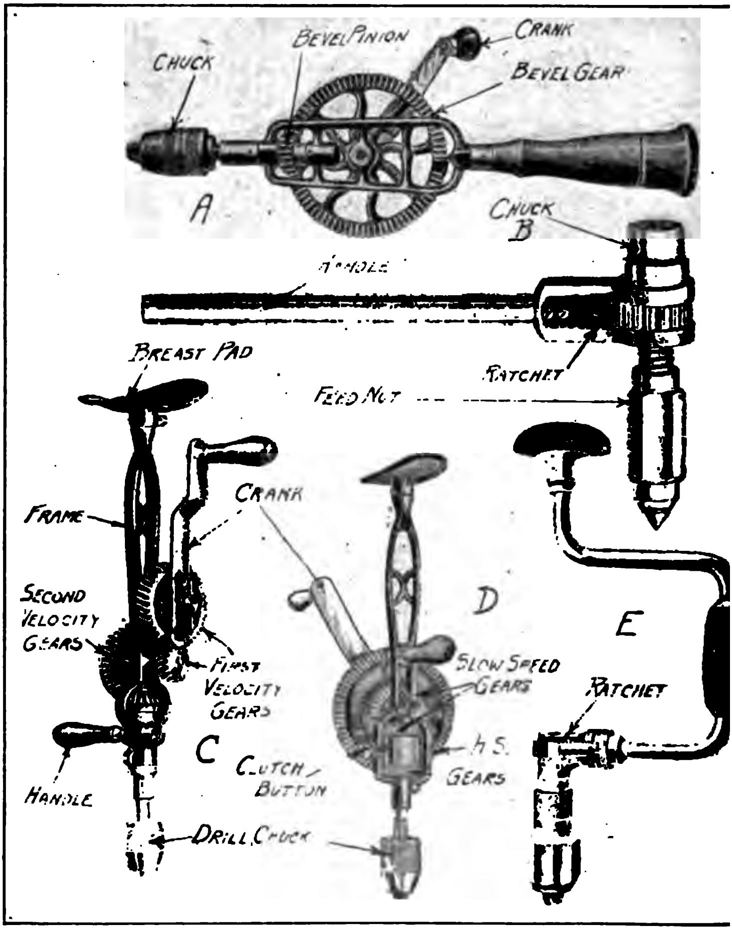


Fig. 59.—Forms of Hand Operated Drilling Machines.

ich the hand drill presses shown at C and D are used. These have pad at the upper end by which pressure may be exerted with the east in order to feed the drill into the work, and for this reason hey are termed "breast drills." The form at C, has compound earing, the drill chuck being driven by the usual form of bevel inion in mesh with a larger bevel gear at one end of a countershaft. A small helical spur pinion at the other end of this countershaft eceives its motion from a larger gear turned by the hand crank. his arrangement of gearing permits of high spindle speed without the use of large gears, as would be necessary if but two were sed. The form at D, gives two speeds, one for use with small rills is obtained by engaging the lower bevel pinion with the uck spindle and driving it by the large ring gear. The slow speed s obtained by shifting the clutch so that the top bevel pinion drives he drill chuck. As this meshes with a gear but slightly larger in iameter, a slow speed of the drill chuck is possible. Breast drills re provided with a handle screwed into the side of the frame, hese are used to steady the drill press. For drilling extremely arge holes which are beyond the capacity of the usual form of drill ress the ratchet form shown at B, may be used or the bit brace utlined at E. The drills used with either of these have square hanks, whereas those used in the drill presses have round hanks. The bit brace is also used widely in wood work and the orm shown is provided with a ratchet by which the bit chuck may e turned through only a portion of a revolution in either direction f desired.

One of the most difficult things to do in connection with installing accessories such as tire irons, license hangers, special amp brackets, trunk racks, etc., is drilling holes in the pressed teel frame of the chassis, as the special alloy steel used for this purpose at the present time requires considerable exertion if one ttempts to bore the hole with an ordinary breast drill. Electrically perated drills have a great advantage when used in making small oles but when they have sufficient capacity to take drills over ½-ch in diameter they are bulky to handle. These are of obvious tility when electrical current is available, but all shops are not o provided and many workmen *do not like to* use them because

of danger of shocks through short circuiting, or the liabi getting out of order, or of injuring the operator, should tl point catch and the drill body be knocked out of the wor hand. A handy tool that has many applications is shown

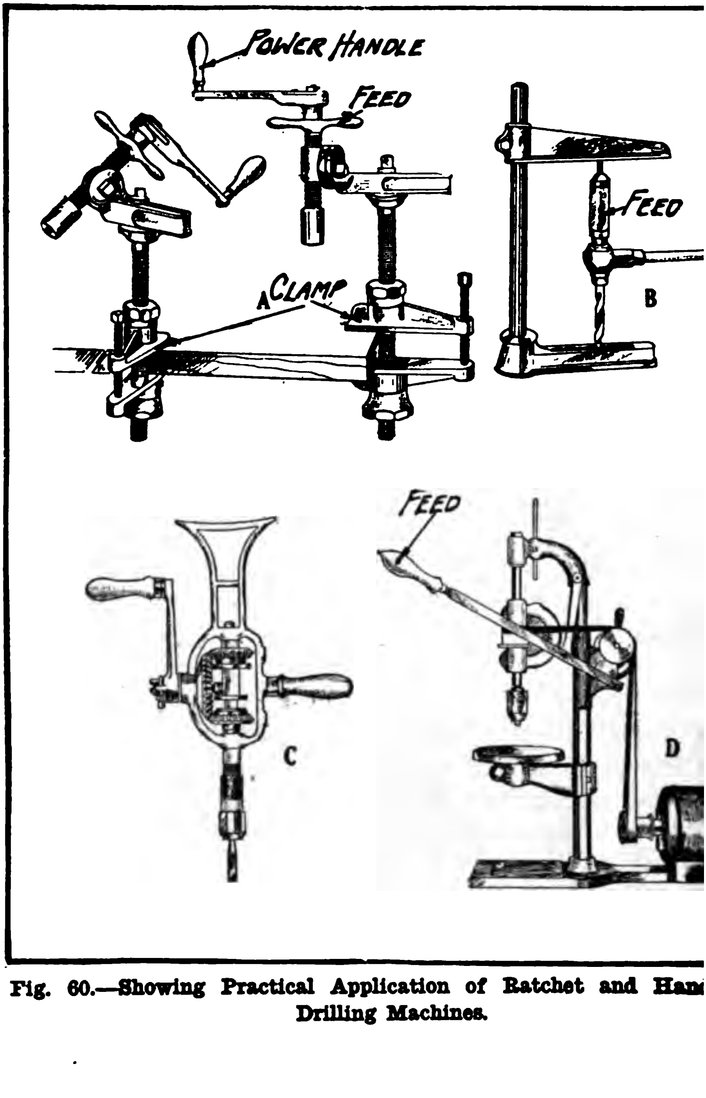


Fig. 60.—Showing Practical Application of Ratchet and Han Drilling Machines.

A. This is mounted on a clamp bracket, has a screw feed, can ill holes at any angle and offers a wide range of adjustment all directions. These are made in three sizes, one taking any ill up to ⅝-inch, a medium size that can be used up to 1 inch in ameter and a larger model that will bore holes as large as 1¼ ches in diameter. The medium size tool will be found sufficiently ge to answer the requirements of any repair shop. The chucks ovided will take either square shank or standard taper shank ills. It will be evident that this fitting can be easily clamped to y part of the frame and that large holes may be drilled with ease account of the leverage provided. A somewhat similar fixture shown at Fig. 60, B, this being in use with the ratchet drill own at Fig. 59, D. The fixture, which is known as the "old an" in repair shop parlance consists of a vertical post attached a slotted base that can be clamped in any desired position by lts or straps. The ratchet drill has a hand-operated screw feed d the arm against which the pressure of the drill is exerted may raised, lowered or swung around to any desired position. A ting of this nature may be used in connection with a wide variety ratchet heads. The advantage of the ratchet arrangement is that permits one to drill holes in places where it would not be possible turn a hand drill as the lever can be oscillated through a small e of a circle instead of a complete revolution. The special form drill press shown at Fig. 60, C, can be changed over by a gle trip from a drilling machine that will give a continual rotary otion to the chucks to a form that will give only an oscil-ting motion which is desirable in valve grinding. Another form electrically operated sensitive drill press for the repairshop rk-bench is shown at Fig 60, D. This differs in construction om that previously described in Chapter I, only in the method drive which is by belt instead of friction discs.

Minor drilling operations with an ordinary hand drill are some-mes made difficult by the inability of the operator to hold the ill perfectly straight. The usual custom is to allow the head the drilling tool to rest against the chest so that one hand may used to get the brace straight and the other to turn the handle. s method requires *much exertion, especially* when a fixed piece

of metal is to be drilled and there is always a possibility of hole being too large or drills breaking, due to swaying of the d press. A very simple piece of apparatus described by Motor is shown at Fig. 61. This easily made jig enables the oper to keep the drill perfectly straight because one hand can be u to steady the drill. The jig is made of wood and of any venient size to accommodate the particular drill press used.

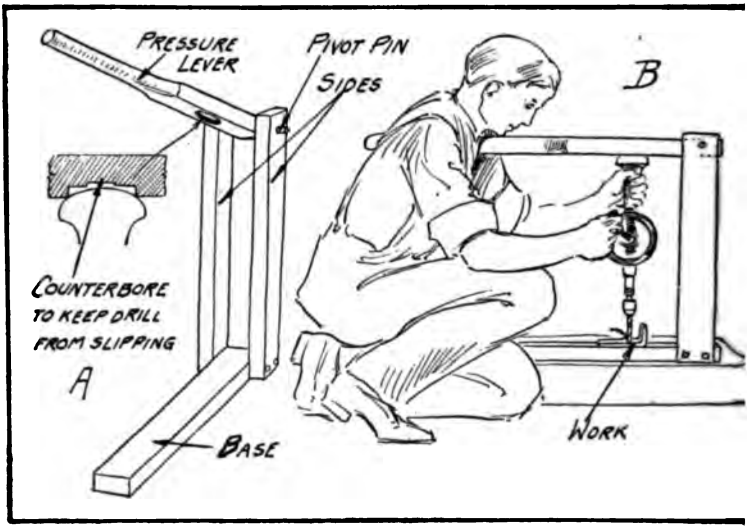
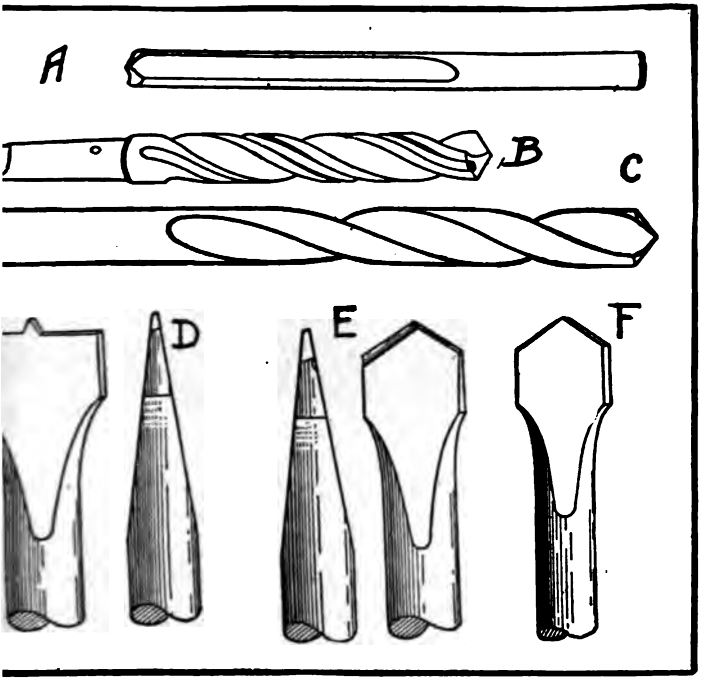


Fig. 61.—How to Use Hand Drills in Simple Homemade Drill Pre

consists of a block of wood forming a base with two upri rigidly fastened to it by screws or bolts. These are drilled at t upper ends to take a piece of three-eighths inch steel rod wl forms the fulcrum for the feed lever which is held under arm, as the illustration clearly shows. A hole is drilled in arm lever to take the head of the drill brace, as the detail sh or if a breast drill is used instead of the hand drill, two pi may be attached to keep the breast drill pad from turning, at each side of that member. A drill press of this nature ca *easily* made from the odds and ends found in any repair shop

ially recommended to the motorist who likes to make his chanical repairs. The work to be operated on can be held by driving nails at the side or a simple vise to clamp the ay be readily extemporized.

ls, Reamers, Taps and Dies.—In addition to the larger maols and the simple hand tools previously described, an essen-



.—**Forms of Drills Used in Hand and Power Drilling Machines.**

n of equipment of any automobile repair shop, even in here the ordinary machine tools are not provided, is a comatfit of drills, reamers, and threading tools. Drills are general classes, the flat and the twist drills. The flat s an angle between cutting edges of about 110 degrees and ly made from special *steel commercially* known as drill rod.

A flat drill cannot be fed into the work very fast because moves metal by a scraping, rather than a cutting process. twist drill in its simplest form is cylindrical throughout tl tire length and has spiral flutes which are ground off at tl to form the cutting lip and which also serve to carry the chips out of the holes. The simplest form of twist drill is shown at Fig. 62, C, and is known as a "chuck" drill b it must be placed in a suitable chuck to turn it. A twis

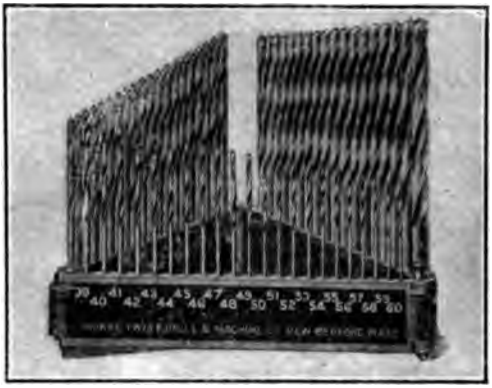


Fig. 63.—Useful Set of Number Drills, Showing Stand for Keeping in an Orderly Manner.

removes metal by cutting and it is not necessary to use a feed as the drill will tend to feed itself into the work.

Larger drills than 3/4-inch are usually made with a t shank as shown at Fig. 62, B. At the end of the taper a tor formed which engages with a suitable opening in the collet, piece used to support the drill is called. The object of this is to relieve the tapered portion of the drill from the st driving by frictional contact alone, as this would not turn th positively and the resulting slippage would wear the sock depreciation changing the taper and making it unfit for drills. The tongue is usually proportioned so it is ad *to drive the* drill under any condition. A small keyway i

ded in the collet into which a tapering key of flat stock may be riven against the end of the tongue to drive the drill from the pindle. A standard taper for drill shanks generally accepted by e machine trade is known as the Morse and is a taper of five-ghths of an inch to the foot. The Brown and Sharp form tapers -tenths of an inch to the foot. Care must be taken, therefore, hen purchasing drills and collets, to make sure that the tapers incide, as no attempt should be made to run a Morse taper in a rown and Sharp collet, or vice versa.

Sometimes cylindrical drills have straight flutes, as outlined t Fig. 62, A. Such drills are used with soft metals and are of alue when the drill is to pass entirely through the work. The ouble with a drill with spiral flutes is that it will tend to draw self through as the cutting lips break through. This catching f the drill may break it or move the work from its position. Vith a straight flute drill the cutting action is practically the ame as with the flat drill shown at Fig. 62, E and F.

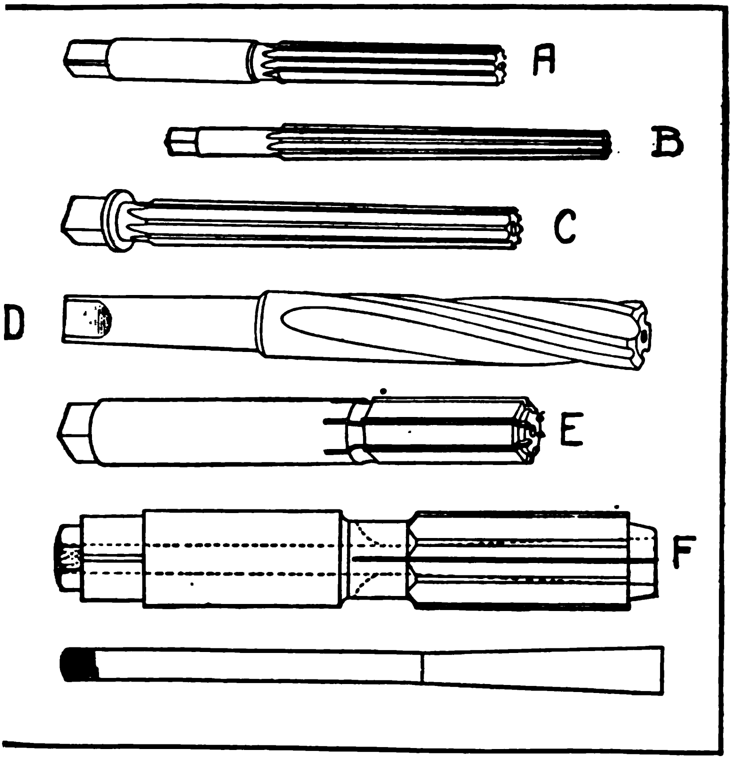
If a drill is employed in boring holes through close-grained, ugh metals, as wrought or malleable iron and steel, the opera-on will be facilitated by lubricating the drill with plenty of lard l or a solution of soda and water. Either of these materials will fectually remove the heat caused by the friction of the metal moved against the lips of the drill, and the danger of heating e drill to a temperature that will soften it by drawing the mper is minimized. In drilling large or deep holes it is good actice to apply the lubricating medium directly at the drill int. Special drills of the form shown at Fig. 62, D, having a iral oil tube running in a suitably formed channel, provides mmunication between the point of the drill and a suitable re-iving hole on a drilled shank. The oil is supplied by a pump d its pressure not only promotes positive circulation and re-val of heat, but also assists in keeping the hole free of chips. drilling steel or wrought iron, lard oil applied to the point of drill will facilitate the drilling, but this material should never used with either brass or cast iron. Tables will be found in last chapter giving drill speeds and feeds and other data ive to the use of this *tool.*

The sizes to be provided depend upon the nature of th(and the amount of money that can be invested in drills. common practice to provide a set of drills, such as shown at F which are carried in a suitable metal stand, these being kn(number drills on account of conforming to the wire gauge ards. Number drills do not usually run higher than $\frac{5}{16}$ i diameter. Beyond this point drills are usually sold by the dia A set of chuck drills ranging from $\frac{3}{8}$ to $\frac{3}{4}$ inch, advanci $\frac{1}{32}$ inch, and a set of Morse taper shank drills ranging from $1\frac{1}{4}$ inches, by increments of $\frac{1}{16}$ inch, will be all that is need the most pretentious repair shop, as it is cheaper to bore larger than $1\frac{1}{4}$ inches with a boring tool than it is to carry a ber of large drills in stock that would be used very seldom, p not enough to justify their cost.

In grinding drills, care must be taken to have the lips same length, so that they will form the same angle with th If one lip is longer than the other, as shown in the flat d Fig. 62, E, the hole will be larger than the drill size, and work of cutting will come upon the longest lip. The dril should be symmetrical, as shown at Fig. 62, F.

It is considered very difficult to drill a hole to an exact eter, but for most work a variation of a few thousandths of a is of no great moment. Where accuracy is necessary, holes be reamed out to the required size. In reaming, a hole is about $\frac{1}{32}$ inch smaller than is required, and is enlarged with ting tool known as the reamer. Reamers are usually of the form shown at Fig. 64, A. Tools of this nature are not de to remove considerable amounts of metal, but are intend augment the diameter of the drill hole by only a small fr of an inch. Reamers are tapered slightly at the point in that they will enter the hole easily, but the greater port the fluted part is straight, all cutting edges being parallel. reamers are made in either the straight or taper forms, that Fig. 64, being straight, while B has tapering flutes. Th intended to be turned by a wrench similar to that employ turning a tap, as shown at Fig. 66, C. The reamer sho *Fig. 64, C,* is a hand reamer of the taper form widely u

smiths. The form at D has spiral flutes similar to a twist and as it is provided with a taper shank it is intended to rned by power through the medium of a suitable collet. s the solid reamers must become reduced in size when sharp- various forms of inserted blade reamers have been designed.



64.—Illustrating Standard Forms of Hand and Machine Reamers.

of these is shown at Fig. 64, E, and as the cutting surfaces me reduced in diameter it is possible to replace the worn blades others of proper size. Expanding reamers are of the form at Fig. 64, F. These have a bolt passing through that fits tapering hole in the interior of the split reamer portion of

the tool. If the hole is to be enlarged a few thousandths of it is possible to draw up on the nut just above the squ of the shank, and by drawing the tapering wedge farther reamer body, the cutting portion will be expanded and a larger hole.

Reamers must be very carefully sharpened or there v

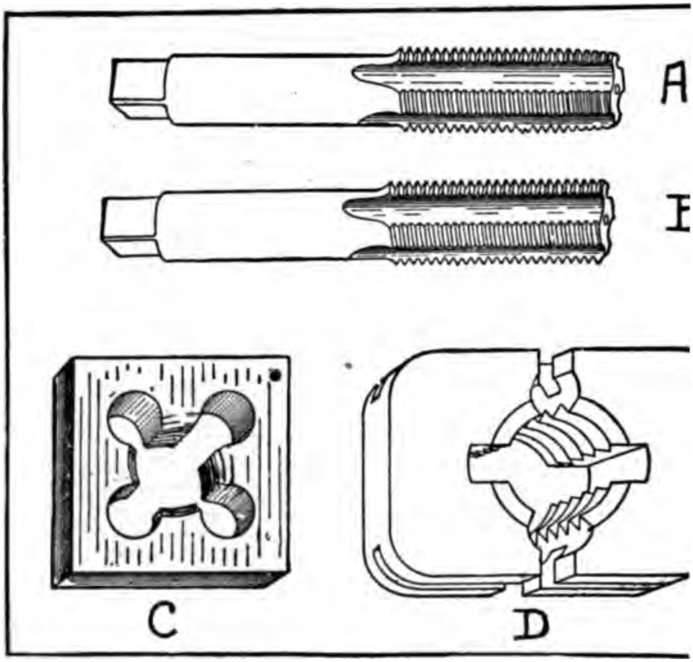


Fig. 65.—Tools for Thread Cutting.

tendency toward chattering with a consequent producti rough surface. There are several methods of preventing t tering, one being to separate the cutting edges by irregula while the most common method, and that to be preferre chine reamers, is to use spiral flutes, as shown at Fig Special taper reamers are made to conform to the vario *pin sizes* which are widely used in holding parts togeth

automobile. A taper of $\frac{1}{16}$ inch per foot is intended for holes where a pin, once driven in, is to remain in place. When it is desired that the pin be driven out, the taper is made steeper, generally $\frac{1}{4}$ inch per foot, which is the standard taper used on taper pins.

When threads are to be cut in a small hole, it will be apparent that it will be difficult to perform this operation economically on a lathe, therefore when internal threading is called for, a simple device known as a "tap" is used. There are many styles of taps, all conforming to different standards. Some are for metric or foreign threads, some conform to the American standards, while others are used for pipe and tubing. Hand taps are the form most used in repair shops, these being outlined at Fig. 65, A and B. They are usually sold in sets of three, known respectively as taper, plug, and bottoming. The taper tap is the one first put into the hole, and is then followed by the plug tap which cuts the threads deeper. If it is imperative that the thread should be full size clear to the bottom of the hole, the third tap of the set, which is straight-sided, is used. It would be difficult to start a bottoming tap into a hole because it would be larger in diameter at its point than the hole. The taper tap, as shown at A, Fig. 65, has a portion of the cutting lands ground away at the point in order that it will enter the hole. The manipulation of a tap is not hard, as it does not need to be forced into the work, as the thread will draw it into the hole as the tap is turned. The tapering of a tap is done so that no one thread is called upon to remove all of the metal, as for about half way up the length of the tap each succeeding thread is cut a little larger by the cutting edge until the full thread enters the hole. Care must be taken to always enter a tap straight in order to have the thread at correct angles to the surface.

In cutting external threads on small rods or on small pieces, such as bolts and studs, it is not always economical to do this work on the lathe, especially in repair work. Dies are used to cut threads on pieces that are to be placed in tapped holes that have been threaded by the corresponding size of tap. Dies for small work are often made solid, as shown at Fig. 66, C, but solid dies

are usually limited to sizes below ½ inch. Sometimes the s is cylindrical in shape, with a slot through one side which one to obtain a slight degree of adjustment by squeezing th portion together. Large dies, or the sizes over ½ inch, are

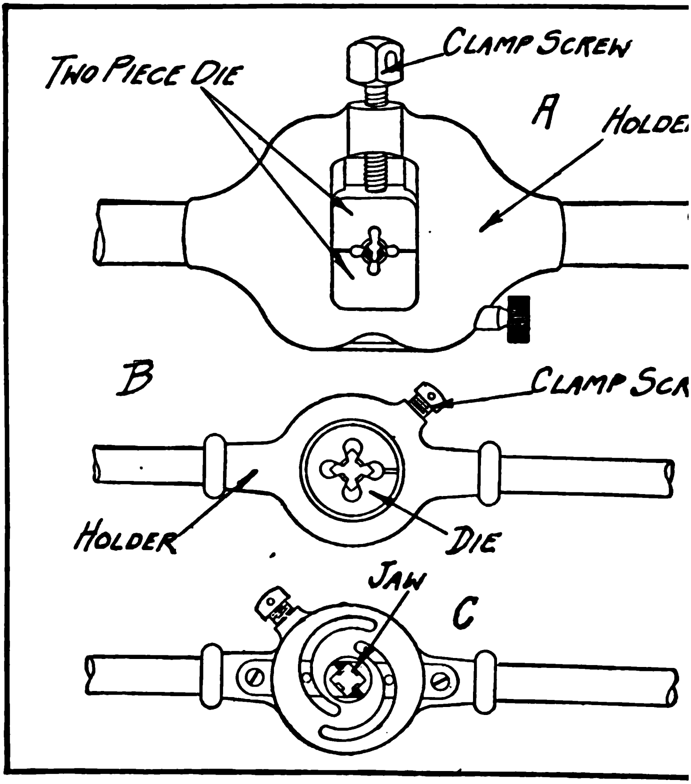


Fig. 66.—Showing Holder Designs for One and Two Piece Thread Dies.

made in two pieces in order that the halves may be cl or brought nearer together. The advantage of this forn is that either of the two pieces may be easily sharpened, *it may* be adjusted very easily the thread may be cut

ges. For example, the die may be adjusted to cut large, which ll produce a shallow thread that will act as an accurate guide en the die is closed up and a deeper thread cut.

A common form of die holder for an adjustable die is shown Fig. 66, A. As will be apparent, it consists of a central body rtion having guide members to keep the die pieces from falling t and levers at each end in order to permit the operator to ert sufficient force to remove the metal. The method of adsting the depth of thread with a clamp screw when a two-piece e is employed is also clearly outlined. The diestock shown at B

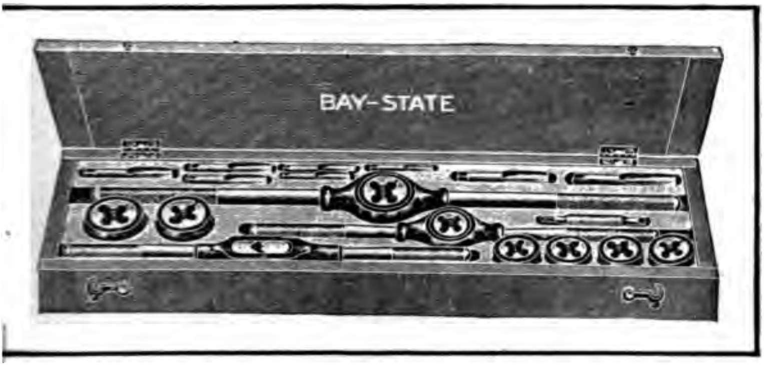


Fig. 67.—**Useful Outfit of Taps and Dies for the Automobile Repair Shop.**

used for the smaller dies of the one-piece pattern, having a slot order that they may be closed up slightly by the clamp screw. he reverse side of the diestock shown at B is outlined below it, nd the guide pieces, which may be easily moved in or out, acrding to the size of the piece to be threaded by means of ecntrically disposed semi-circular slots in the adjustment plate, are own. These movable guide members have small pins let into eir surface which engage the slots, and they may be moved in out, as desired, according to the position of the adjusting plate. e use of the guide pieces makes for accurate positioning or cenng of the rod to be threaded. Dies are usually sold in sets, s are commonly furnished as a *portion of a* complete outfit

such as outlined at Fig. 67. That shown has two sizes stock, a tap wrench, eight assorted dies, eight assorted tap small screw driver for adjusting the die. An automobil shop should be provided with three different sets of taps a as three different standards for the bolts and nuts are fastening automobile components. These are the Americar (used on foreign cars), and the S. A. E. standard threads of pipe dies and taps will also be found useful.

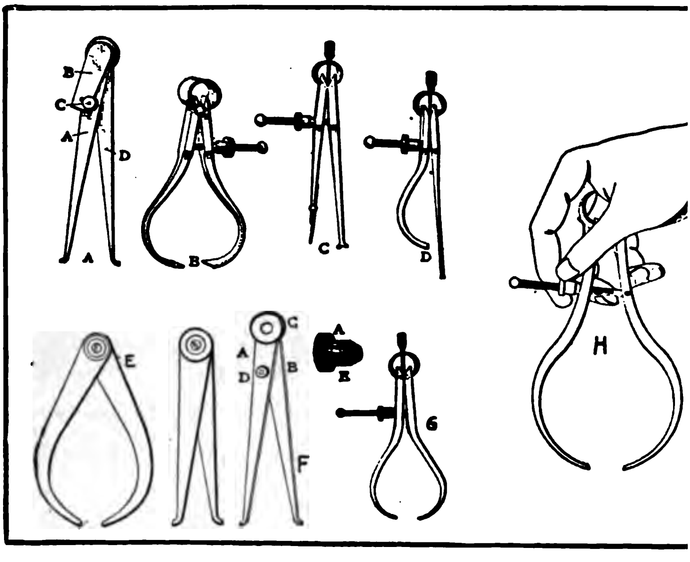
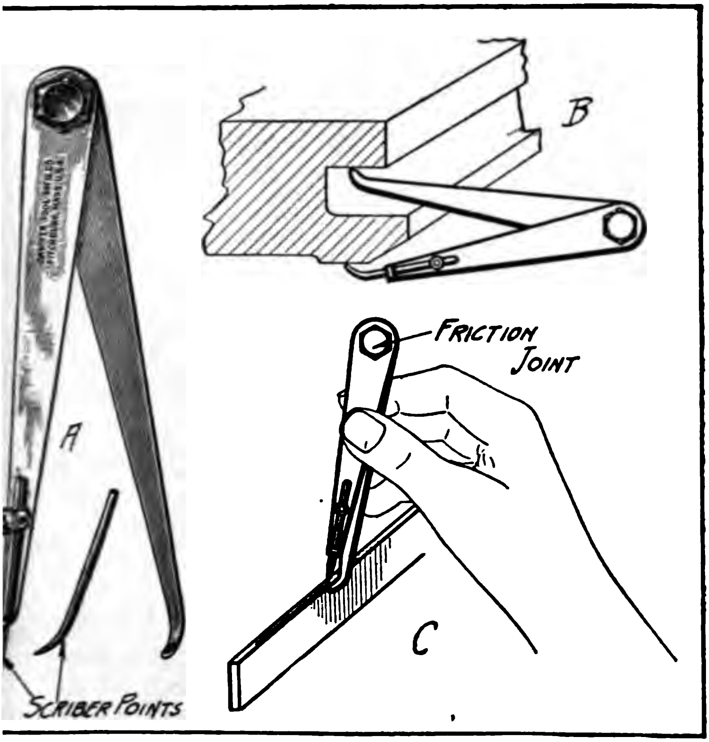


Fig. 68.—Common Forms of Inside and Outside Calipers.

Measuring Tools.—The tool outfit of the machinist or chanic who aspires to do machine work must include a of measuring tools which are not needed by the floor one who merely assembles and takes apart the finished The machinist who must convert raw material into finish ucts requires a number of measuring tools, some of wl used for taking only approximate measurements, such as *and scales*, while others are intended to take very accura

its, such as the Vernier and the micrometer. A number of n forms of calipers are shown at Fig. 68. These are known de or outside calipers, depending upon the measurements e intended to take. That at A is an inside caliper, consisting legs, A and D, and a gauging piece, B, which can be locked



9.—View Showing Utility of Combination Inside and Outside Friction Joint Calipers.

A, or released from that member by the screw, C. The of this construction is to permit of measurements being taken bottom of a two diameter hole, where the point to be ed is of larger diameter than the portion of the hole through the calipers entered. *It will be apparent* that the legs

A and D must be brought close together to pass through the smaller holes. This may be done without losing the setting, as the guide bar B will remain in one position as determined by the size of the hole to be measured, while the leg A may be swung in to clear the obstruction as the calipers are lifted out. When it is desired to ascertain the measurements the leg A is pushed back into place into the slotted portion of the guide B, and locked by the clamp screw C. A tool of this form is known as an internal transfer caliper.

The form of caliper shown at B is an outside caliper. Those at C and D are special forms for inside and outside work, the former being used, if desired, as a divider, while the latter may be employed for measuring the walls of tubing. The calipers at E are simple forms, having a friction joint to distinguish them from the spring calipers shown at B, C and D. In order to permit of ready adjustment of a spring caliper, a split nut as shown at G is sometimes used. A solid nut caliper can only be adjusted by screwing the nut in or out on the screw, which may be a tedious process if the caliper is to be set from one extreme to the other several times in succession. With a slip nut as shown at G it is possible to slip it from one end of the thread to the other without turning it, and of locking it in place at any desired point by simply allowing the caliper leg to come in contact with it. The method of adjusting a spring caliper is shown at Fig. 68, H. The caliper shown at Fig. 69, A, is known as a "hermaphrodite," and is so called because it can be used for measuring both diameters of pieces or bores of holes. It is provided with a removable and adjustable point, two being provided with each device. One of these is curved, the other is straight. The point is firmly held in position by a knurled nut and washer and draw bolt, and is given additional support by the loop at the end of the caliper leg. The auxiliary caliper point furnished with these tools makes it possible to convert the tools readily into an inside caliper. Two uses of this tool are shown at Fig. 69, B and C. These are self-explanatory.

An important tool that should be included in the equipment of every shop where machine tools are used is shown at Fig. 70, A.

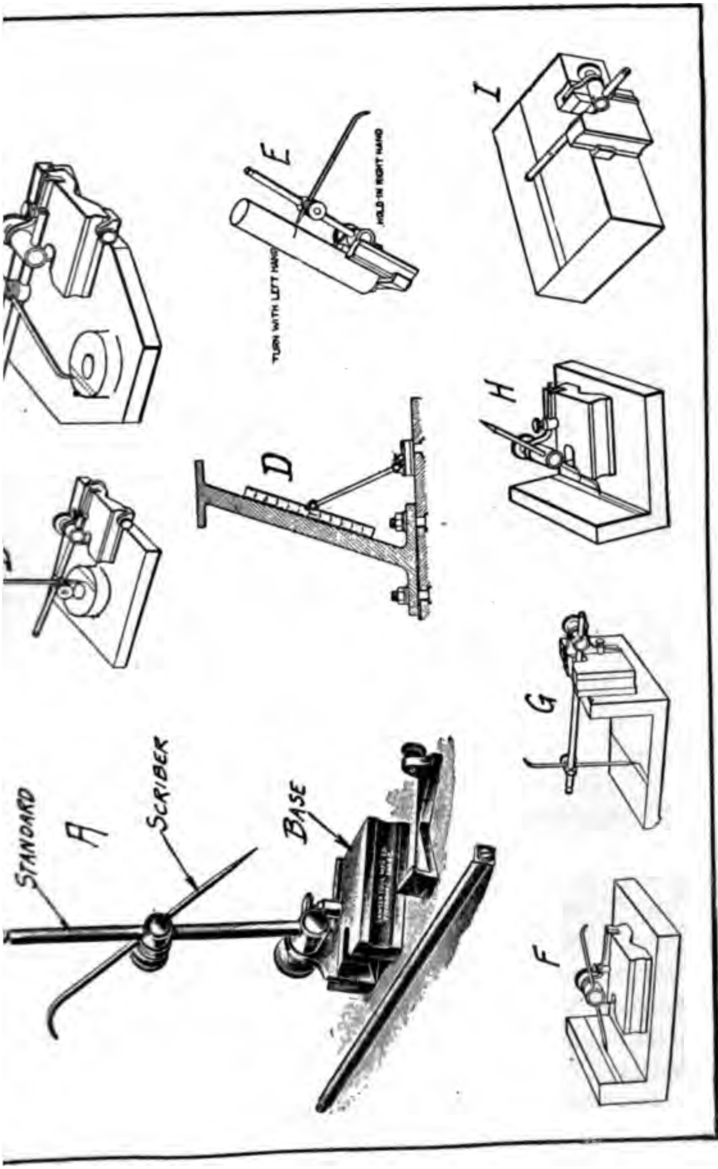
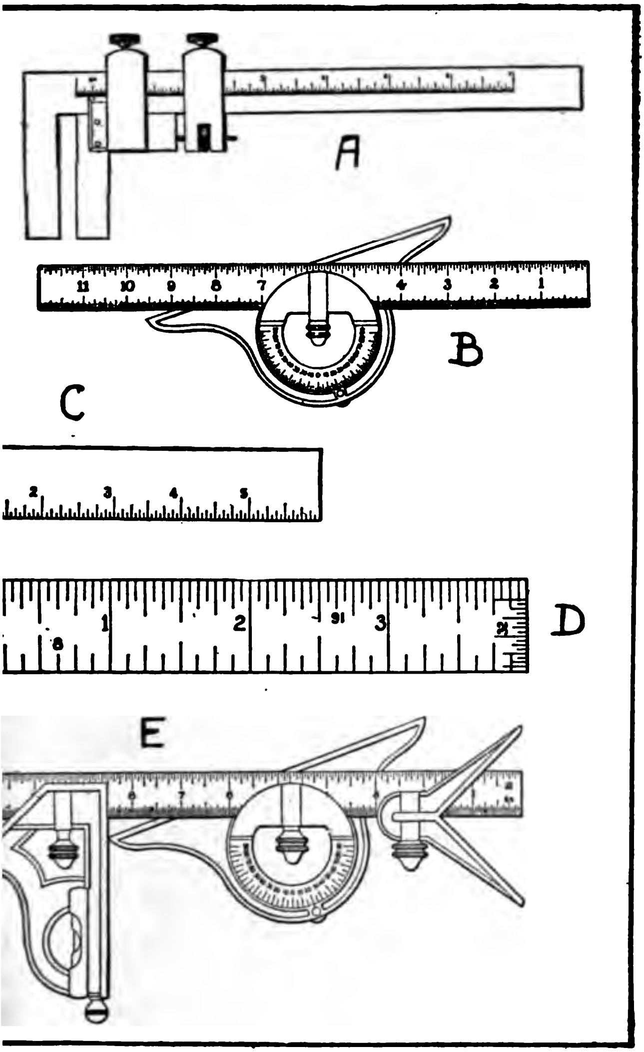


Fig. 70.—Illustrating Typical Surface Gauge and Methods of Using.

This is used in connection with the surface plate or the bed of a drill press or planer, and will serve many purposes. The tool shown is provided with three spindles ranging from nine to eighteen inches in length, and the construction admits of swinging the standard three-quarters of the distance around the base. The adjusting mechanism is so arranged that it can be set at any desired position. The clamping devices are rigid and firm and are not susceptible to slipping. The application at B shows the use in laying out lines on the boss of a casting where the scriber point can be placed directly over the boss. The application at C shows the method of making these lines where the scriber point support must be offset and placed at some distance from the boss to be marked. At D the surface gauge is shown used in connection with a scale in order to make measurements and secure the alignment of an angular I section casting. At E the method of scribing a line around a piece of barstock or tube is shown. The remaining illustrations show the uses of the surface gauge in laying out work of various kinds. Many other combinations are possible besides those shown, as a tool of this nature can be used as a bench gauge, scribing block or depth gauge.

Among the most common of the machinist's tools are those used for linear measurements. The usual forms are shown in group, Fig. 71. The most common tool, which is widely known, is the carpenter's folding two-foot rule or the yardstick. While these are very convenient for taking measurements where great accuracy is not required, the machinist must work much more accurately than the carpenter, and the standard steel scale which is shown at Fig. 71, D, is a popular tool for the machinist. The steel scale is in reality a graduated straight edge and forms an important part of various measuring tools. These are made of high grade steel and vary from 1 to 48 inches in length. They are carefully hardened in order to preserve the graduations, and all surfaces and edges are accurately ground to insure absolute parallelism. The graduations on the high grade scales are produced with a special device known as a dividing engine, but on cheaper scales, etching suffices to provide a fairly accurate graduation. The steel scales may be very thin and flexible, or may



Measuring Appliances for the Machinist and Floor Man.

be about an eighth of an inch thick on the twelve-inch size, which is that commonly used with combination squares, protractors and other tools of that nature. The repairman's scale should be graduated both with the English system, in which the inches are divided into eighths, sixteenths, thirty-secondths and sixty-fourths, and also in the metric system, divided into millimeters and centimeters. Some machinists use scales graduated in tenths, twentieths, fiftieths and hundredths. This is not as good a system of graduation as the more conventional one first described.

Some steel scales are provided with a slot or groove cut the entire length on one side and about the center of the scales. This permits the attachment of various fittings such as the protractor head, which enables the machinist to measure angles, shown at Fig. 70, B, or in addition the heads convert the scale into a square or a tool permitting the accurate bisecting of pieces of circular section. Two scales are sometimes joined together to form a right angle, such as shown at Fig. 70, C. This is known as a square and is very valuable in ascertaining the truth of vertical pieces that are supposed to form a right angle with a base piece. The Vernier is a device for reading finer divisions on a scale than those into which the scale is divided. Sixty-fourths of an inch are about the finest division that can be read accurately with the naked eye. When fine work is necessary a Vernier is employed. This consists essentially of two rules so graduated that the true scale has each inch divided into ten equal parts, the upper or Vernier portion has ten divisions occupying the same space as nine of the divisions of the true scale. It is evident, therefore, that one of the divisions of the Vernier is equal to nine-tenths of one of those on the true scale. If the Vernier scale is moved to the right so that the graduations marked "1" shall coincide, it will have moved one-tenth of a division on the scale or one-hundredth of an inch. When the graduations numbered 5 coincide the Vernier will have moved five-hundredths of an inch; when the lines marked 0 and 10 coincide, the Vernier will have moved nine-hundredths of an inch, and when 10 on the Vernier comes opposite 10 on the scales, the upper rule will have moved ten-hundredths of an inch, or the *whole of one division* on the scale. By this means the scale

though it may be graduated only to tenths of an inch, may be accurately set at points with positions expressed in hundredths of an inch. When graduated to read in thousandths, the true scale is divided into fifty parts and the Vernier into twenty parts. Each division of the Vernier is therefore equal to nineteen-twentieths of one of the true scale. If the Vernier be moved so the lines of

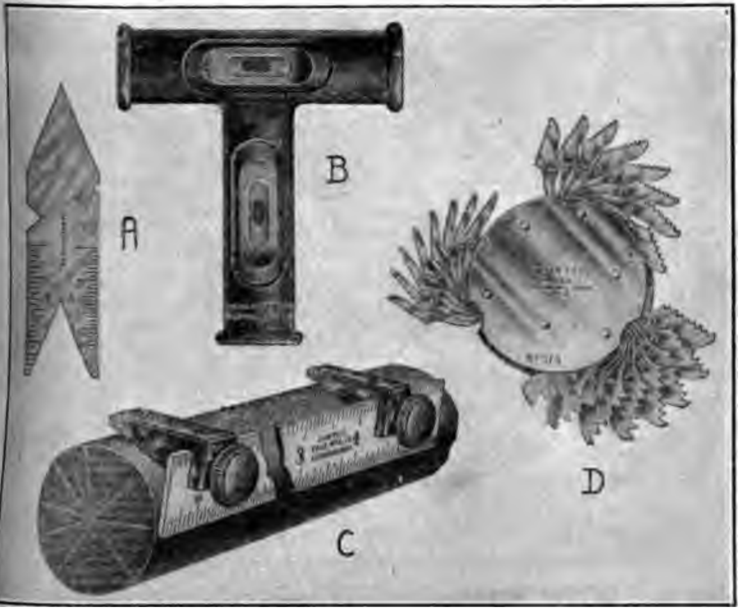


Fig. 72.—Measuring Appliances of Value in Automobile Repair Work.

the first division coincide, it will have moved one-twentieth of one-fiftieth, or .001 inch. The Vernier principle can be readily grasped by studying the section of the Vernier scale and true scale shown at Fig. 73, A.

The caliper scale which is shown at Fig. 71, A, permits of taking the over-all dimension of any parts that will go between the jaws. This scale can be adjusted very accurately by means of fine thread screw attached to movable jaw and the divisions may be divided by eye into *two parts if one* sixty-fourth is the

smallest of the divisions. A line is indicated on the movable and coincides with the graduations on the scale. As will be ap ent, if the line does not coincide exactly with one of the gr ations it will be at some point between the lines and the measurement may be approximated without trouble.

A group of various other measuring tools of value to machinist is shown at Fig. 72. The small scale at A is te a "center gauge," because it can be used to test the trut the taper of either a male or female lathe center. The two sm

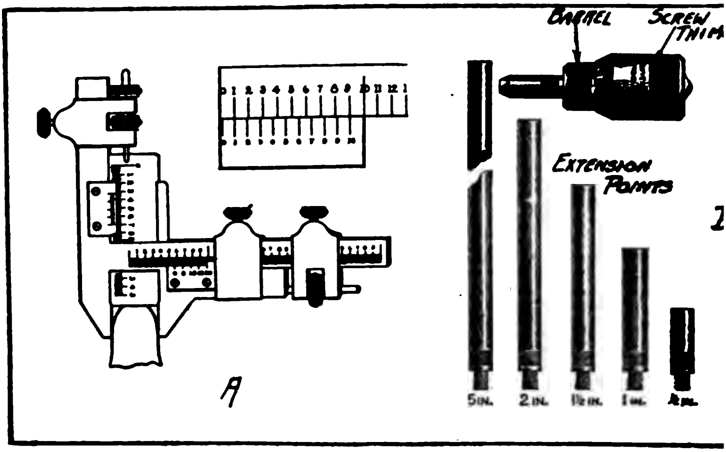


Fig. 73.—At Left, Special Form of Vernier Caliper for Measuring Teeth; at Right, Micrometer for Accurate Internal Measuremen

nicks or v's indicate the shape of a standard thread, and ma used as a guide for grinding the point of a thread-cutting The cross level which is shown at B is of marked utility in ere as it will indicate absolutely if the piece it is used to test is It will indicate if the piece is level along its width as w its length.

A very simple attachment for use with a scale that enabl machinist to scribe lines along the length of a cylindrical pi *shown at* Fig. 72, C. These are merely small wedge-shaped c

having an angular face to rest upon the oars. The thread pitch gauge which is shown at Fig. 72, D, is an excellent pocket tool for the garage mechanic, as it is often necessary to determine without loss of time the pitch of the thread on a bolt or in a nut. This consists of a number of leaves having serrations on one edge corresponding to the standard thread it is to be used in measuring. The tool shown gives all pitches up to 48 threads per inch. The leaves may be folded in out of the way when not in use, and their shape admits of their being used in any position without the remainder of the set interfering with the one in use. The fine pitch gauges have slim, tapering leaves of the correct shape to be used in finding the pitch of small nuts. As the tool is round when the leaves are folded back out of the way, it is an excellent pocket tool, as there are no sharp corners to wear out the pocket. Practical application of a Vernier having measuring heads of special form for measuring gear teeth is shown at Fig. 73, A. As the action of this tool has been previously explained, it will not be necessary to describe it further.

Where great accuracy is necessary in taking measurements the micrometer caliper, which in the simple form will measure easily .001 inch (one-thousandth part of an inch) and when fitted with a Vernier that will measure .0001 inch (one ten-thousandth part of an inch), is used. The micrometer may be of the caliper form for measuring outside diameters or it may be of the form shown at Fig. 73, B, for measuring internal diameters. The operation of both forms is identical except that the internal micrometer is placed inside of the bore to be measured while the external form is used just the same as a caliper. The form outlined will measure from one and one-half to six and a half inches as extension points are provided to increase the range of the instrument. The screw has a movement of one-half inch and a hardened anvil is placed in the end of the thimble in order to prevent undue wear at that point. The extension points or rods are accurately made in standard lengths and are screwed into the body of the instrument instead of being pushed in, this insuring firmness and accuracy. Two forms of micrometers for external measurements are shown at Fig. 74. The top one is *graduated to* read in thousandths

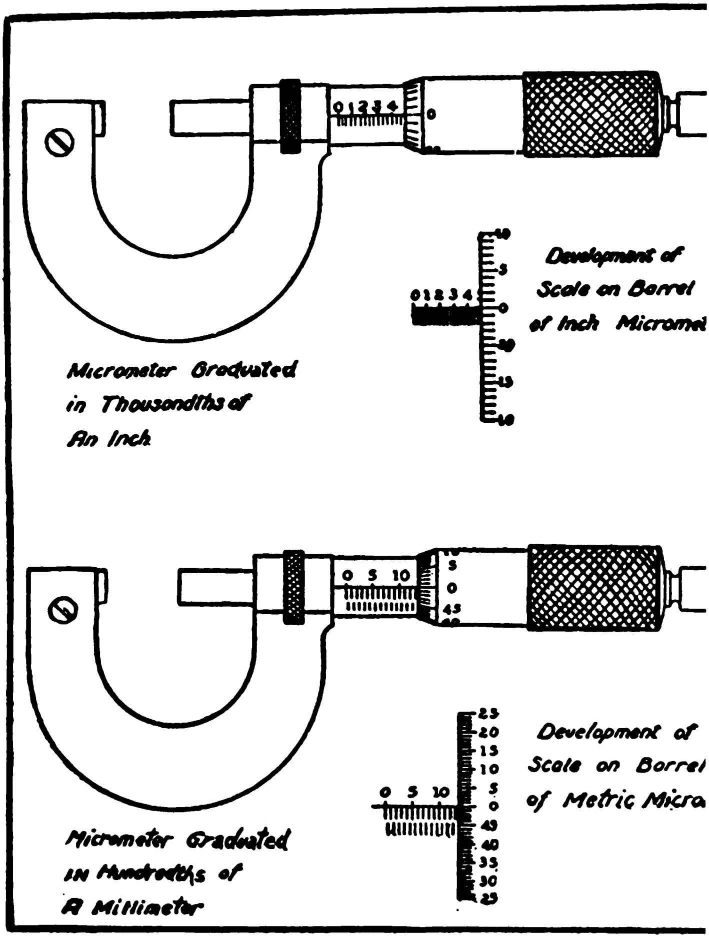


Fig. 74.—Standard Forms of Micrometer Caliper for External M ments.

of an inch, while the lower one is graduated to indicate hun of a millimeter. The mechanical principle involved in t struction of a micrometer is that of a screw free to mo fixed nut. An opening to receive the work to be meas provided by the backward movement of the thimble whic

he screw and the size of the opening is indicated by the gradu- ıtions on the barrel.

The article to be measured is placed between the anvil and spindle, the frame being held stationary while the thimble is revolved by the thumb and finger. The pitch of the screw thread on the concealed part of the spindle is 40 to an inch. One complete revolution of the spindle, therefore, moves it longitudinally one-fortieth, or twenty-five thousandths of an inch. As will be evident from the development of the scale on the barrel of the inch micrometer, the sleeve is marked with forty lines to the inch, each of these lines indicating twenty-five thousandths. The thimble has a beveled edge which is graduated into twenty-five parts. When the instrument is closed the graduation on the beveled edge of the thimble marked 0 should correspond to the 0 line on the barrel. If the micrometer is rotated one full turn he opening between the spindle and anvil will be .025 inch. If he thimble is turned only one graduation, or one twenty-fifth of a evolution, the opening between the spindle and anvil will be ncreased only by .001 inch (one-thousandth of an inch).

As many of the dimensions of the automobile parts, especially f those of foreign manufacture or such parts as ball and roller earings, are based on the metric system, the automobile repairman hould possess both inch and metric micrometers in order to avoid ontinual reference to a table of metric equivalents. With a ıetric micrometer there are fifty graduations on the barrel, these epresenting .01 of a millimeter or approximately .0004 inch. ne full turn of the barrel means an increase of half millimeter, r .50 mm. (fifty one-hundredths). As it takes two turns to augıent the space between the anvil and the stem by increments of ne millimeter, it will be evident that it would not be difficult) divide the spaces on the metric micrometer thimble in halves by ıe eye, and thus the average workman can measure to .0002 inch lus or minus without difficulty. As set in the illustration, the ıetric micrometers show a space of 13.5 mm., or about one milliıeter more than half an inch. The inch micrometer shown is t to five-tenths or five hundred one-thousandths or one-half inch. little study of the foregoing matter will make it easy to under-

stand the action of either the inch or metric micrometer. A tabl of metric equivalents will be found in the back of the book t enable the workman to change inches to millimeters, and vice versa without any trouble.

Both of the micrometers shown have a small knurled knob a the end of the barrel. This controls the ratchet stop, which is device that permits a ratchet to slip by a pawl when more tha a certain amount of pressure is applied, thereby preventing th measuring spindle from turning further and perhaps springin the instrument. A simple rule that can be easily memorized fo reading the inch micrometer is to multiply the number of vertica divisions on the sleeve by 25 and add to that the number of di visions on the bevel of the thimble reading from the zero to th line which coincides with the horizontal line on the sleeve. Fo example: if there are ten divisions visible on the sleeve, multipl this number by 25, then add the number of divisions shown o the bevel of the thimble, which is 10. The micrometer is there fore opened 10 x 25 equals 250 plus 10 equals 260 thousandths.

Micrometers are made in many sizes, ranging from those hav ing a maximum opening of one inch to special large forms tha will measure forty or more inches. While it is not to be expecte that the repairman will have use for the big sizes, if a calipe having a maximum opening of six inches is provided with a num ber of extension rods enabling one to measure smaller objects, prac tically all of the measuring needed in repairing automobile part can be made accurately. Two or three smaller micrometers havin a maximum range of two or three inches will also be foun valuable, as most of the measurements will be made with thes tools which will be much easier to handle than the larger sizes.

Lathe Accessories and Lathe Tools.—Mention has been pre viously made of the marked utility of the lathe and its man advantages which make it an indispensable article of repair sho equipment. When one purchases a lathe there are a number o accessories that are usually furnished with that tool without extr cost. These include a large face plate, having a capacity equa to the full swing of the lathe, a steady rest and a follow rest. number of the most important lathe accessories are shown in illu

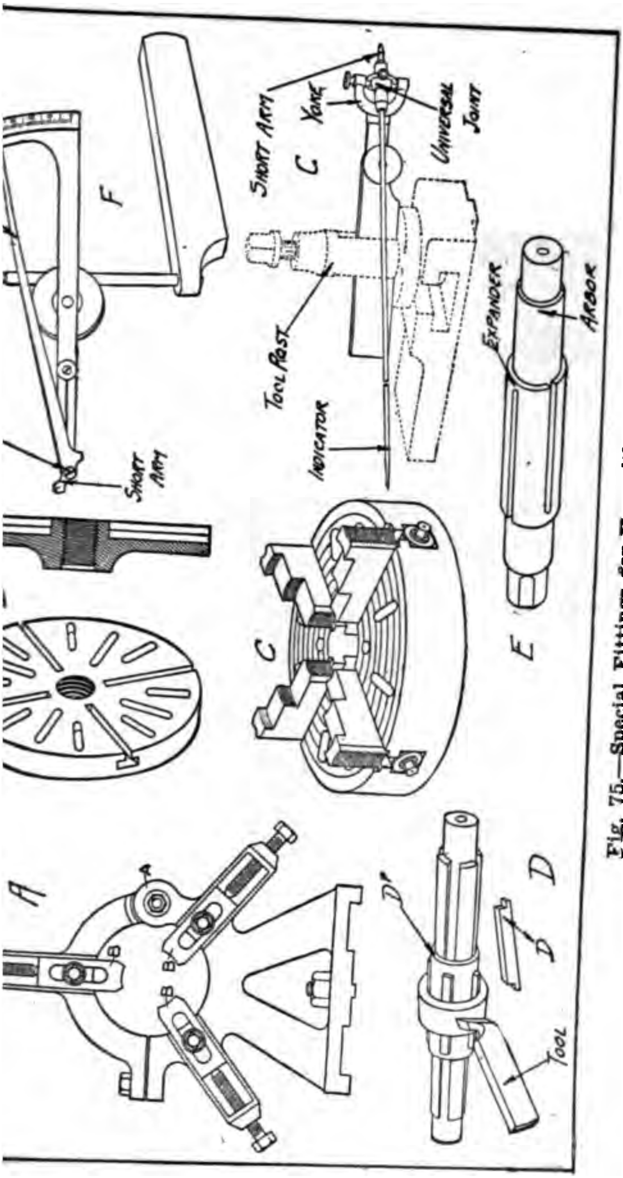
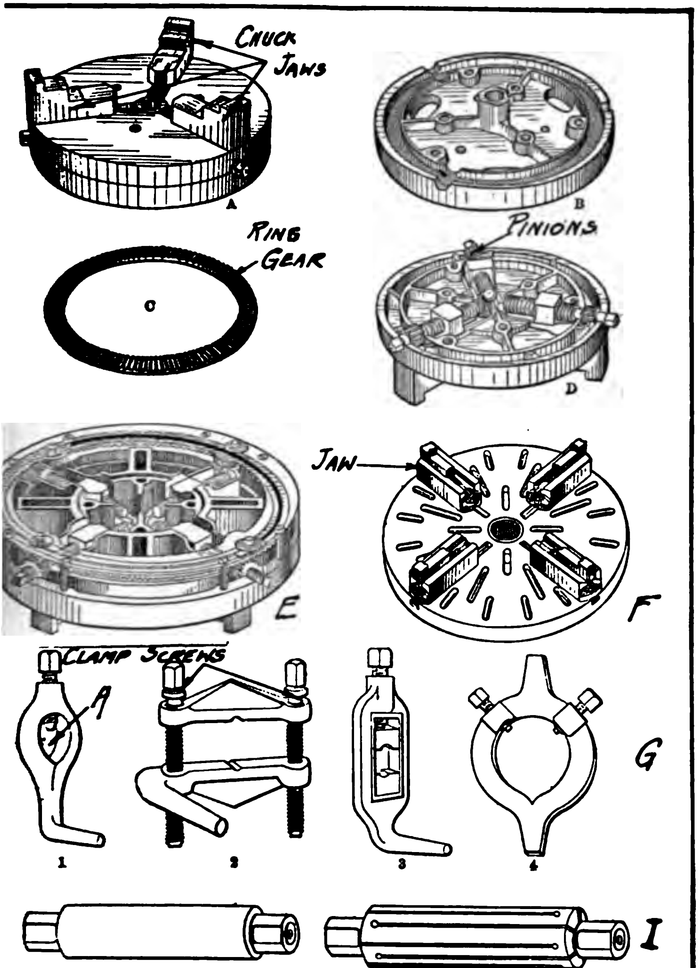


Fig. 75.—Special Fittings for Use with Lathe.

trations Figs. 75 and 76. The steady rest shown at Fig. 75, is used when a long shaft is being turned that cannot be support by the tail stock center. This consists of a frame hinged at having three movable jaws, B, B, B. These jaws may be regulat by suitable screws and can be held firmly in place by setti down the clamping nut when they have been adjusted to form suitable bearing for the piece to be turned. The usual constru tion of a face plate is shown at B. This can be made into a chu by attaching face plate jaws such as are shown at Fig. 76, The face plate is provided with four T-slots to permit the ea insertion of clamping bolts, and also has numerous slots throu the face to permit of bolting on angle plates or other fixtures hold the work. A four-jaw chuck is shown at Fig. 75, C. Th consists of a body fastened to a special face plate in a mann that insures concentricity with the spindle. Chucks may be two types, universal chucks are those in which the four jaws m be controlled by any one of the screw heads while an independe chuck is a form having each jaw controlled by its individu screw independently of the other. Sometimes a chuck may be a combination type, and the work-holding jaws may be operat universally or independently, as desired.

Mandrels or arbors to support work to be turned are sho at D and E. That at D is provided with slots adapted to ta pieces of various heights, making it possible to use the comm arbor as a basis for supporting work of various diameters using the proper filling pieces. One of the filling pieces is sho at B 1, while the piece employed to hold the filling pieces position in the mandrel slots is shown at B 2. The mandrel at is an expanding form, in which a piece may be held tightly moving the expander carrying the piece along the taper of arbor until the piece is firmly held by the enlargement in s of the slotted expander sleeve.

The indicator shown at F, Fig. 75, is intended for centeri work accurately in a chuck or on a face plate. This consists a bell crank having considerable multiplication of leverage, so t a very slight movement of the short arm will mean about times as much of the long arm which serves as an indicat



76.—Outlining Construction of Lathe Chucks and Driving Dogs.

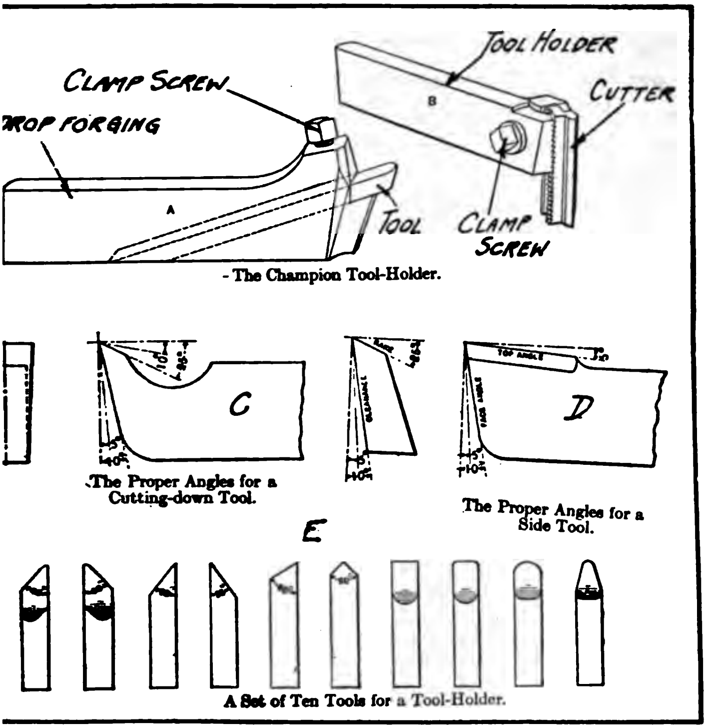
ndicator shown at G is also intended for use in the tool nd is a gauge for indicating the truth of center holes. This a multiplying lever, fulcrumed in a universal joint, sup- by a suitable yoke. The *short arm of* the indicator is

placed in the center, and if that runs out of truth it will gre magnify the amount of running out which will be indicated the degree of movement of the indicator point.

The internal construction of the usual pattern of three universal chuck is clearly outlined at B, C and D, Fig. 76. view at A shows the chuck assembled. That at B shows the bot half, which is attached to the head stock spindle. At C the be rack that is employed to cause the jaw-regulating screws to m in unison is shown. This bevel rack engages the bevel pi shown on the adjusting screws at D. A movement of any of the screws will therefore produce a corresponding and eq movement of the other two. At E the internal mechanism of a fo jaw chuck is shown. At F, a face plate fitted with chuck jaw depicted. When work is supported on a mandrel it is neces to provide some means of turning it, because the frictional c tact on the live center (that carried by the head stock) is sufficient to turn the arbor against the resistance of the cutt tool. Lathe dogs are used to turn the work, these being si clamp members having projecting tails designed to engage of the slots of the face plate. For round work the form sh at G 1, Fig. 76, is commonly used. The shaft or arbor to driven is placed in the hole A, and firmly secured by tight the clamp screw. For work other than round, the lathe dog sh at G 2 is very satisfactory. The lathe dogs at G 3 and 4 special forms that can be used with either round or irreg work. The simplest form of arbor and that commonly used shown at Fig. 76, H. This is a piece of steel ground to standard size, but having a slight taper with the ends flatt to permit of secure holding by the lathe dog clamp screws. W the simple mandrel is a popular form, it has the disadvan that the constant driving on and off of the work will produce preciation and the mandrel will become reduced in size. arbors are usually obtained in sets ground to standard dia varying by thirty-seconds or sixteenths of an inch. It is ceivable that there would be many pieces to be handled that not fit any standard solid arbor. In order to handle the size pieces an expanding support, either of the form sh

», E, or 76, I, can be used. A mandrel of this kind is ar-
so that the pieces designed to grip the work can be forced
against the piece to be turned by locating the expander
' on the taper, which is greater than that of the solid

lathe is complete without a well-selected outfit of cutting



- The Champion Tool-Holder.

.The Proper Angles for a Cutting-down Tool.

The Proper Angles for a Side Tool.

A Set of Ten Tools for a Tool-Holder.

Fig. 77.—Lathe Tool Forms.

which may be obtained in a great variety of forms. One
most popular types for all around work is the "Champion"
lder, which takes various cutting points, which can be read-
nged in the master holder. This is shown at Fig. 77, A,
simple round nose-turning *tool in place.* As will be ap-

parent, the tool which does the cutting is ground from a pie square tool steel of proper size to fit the square hole in the of the tool holder, which is usually a steel forging. Another of "Champion" tool holder used for thread cutting is show B, Fig. 77. The cutter may be adjusted as it wears or is red in size by grinding by loosening the clamp screw and raising cutting tool which is provided with a series of ratchet teeth, then once again tightening the clamp screws which brings ratchet teeth on the cutter and on the tool holder into po engagement. The proper angles for a cutting-down tool are s at C, and a side tool at D. The angle on the front edge of the is known as a clearance angle, while that from the cutting back is known as the rake on a straight cutting-down tool. the side tools there is another angle to be considered, know the top angle. This is clearly indicated. The form of the cut point used depends largely upon the characteristics of the mat to be cut. The first consideration relates to the softness of material, the other to structure, whether it is crystalline like iron or fibrous like wrought iron. The clearance is added to tool to prevent it from rubbing on the work, while the degre rake determines the cutting ability or sharpness of the cutting and gives freedom for the chip to leave the work. A lathe should always be set so the cutting edge will be very nearly point that would correspond to a horizontal line drawn thr the center of the work. If a tool is set too low, it will tend into the work and force it from the centers, whereas if it is s high, the angle of clearance will be reduced and the work rub against the bottom of the tool. Many machinists favor the cutting edge just a little above the center or at a point responding to about five degrees above the horizontal line through the axis.

A complete set of cutting tools for use with the Champio holder, shown at Fig. 77, A, is clearly outlined at Fig. The tools are made of various grades of tool steel, which is carbon alloy capable of being hardened by raising its temp to about 1500 degrees Fahr. and then quenching in water, *brine, according* to the degree of hardness desired. Vario

ontaining tungsten, molybdenum, cobalt, and other sub- are also obtainable, these possessing desirable qualities such ty to keep their edge at greater heat than tool steel of the t high carbon form, or of having greater resistance for tough metals such as the chrome-nickel or chrome-vana- teels so widely used in automobile construction.

Armstrong tool holders are made in a variety of patterns,

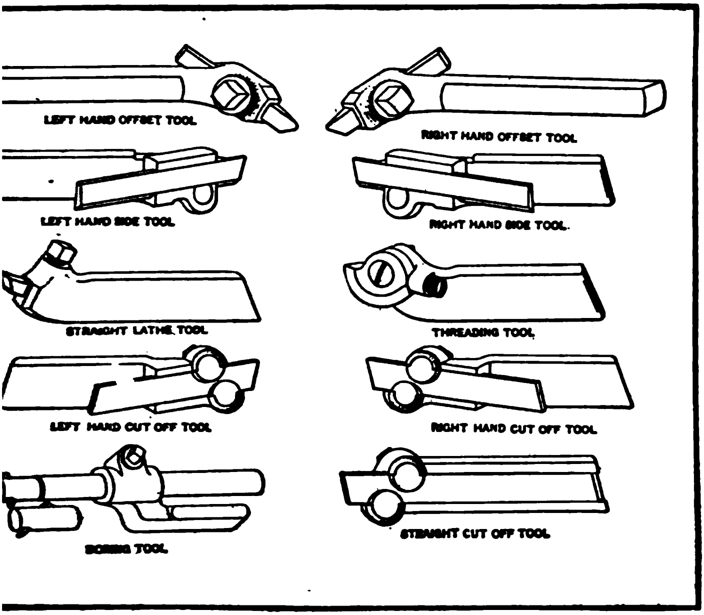


Fig. 78.—Armstrong Tool Holders for Many Uses.

st common of which are shown at Fig. 78. As each is in the illustration, further description is unnecessary. The construction is the same for all tools, the main portion y being a steel forging not subject to deterioration, while tting point or tool is readily removable for grinding or ng. While the tool holder has many advantages, it is ecessary to make special lathe tools such as when turning boring and other operations where the conventional form

of tool holder could not be used to advantage. Before the
of the tool holder, lathe tools were forged of tool steel
blacksmith according to the individual preferences of tl
chinist having the work done. While the forged tools are e
satisfactory, it is not practical to use special cutting steel

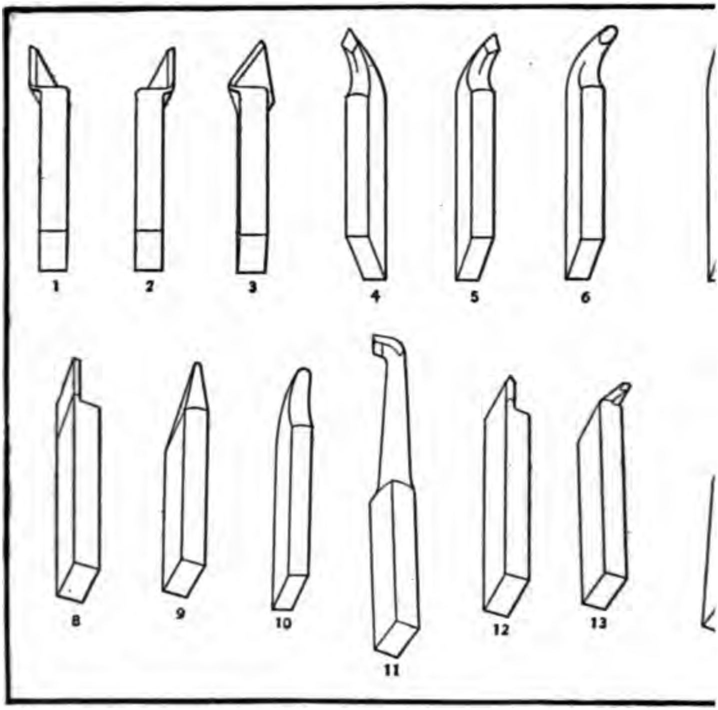


Fig. 79.—Set of Ordinary Hand Forged Cutting Tools for Use in L

count of the great cost of this material. As practically th
point where the high grade steel is desired is around the
edge, it will be apparent that it would be very wasteful
that material for the body of the tool, which could be just
made of a cheaper grade of steel. This, of course, is the
advantage of the Armstrong tool holder and similar devic

of hand-forged tools ordinarily used in lathe work are shown Fig. 79. That at 2 is a right-hand side tool, that at 1 is a left-nd side tool. The others in order are as follows: 3, right-hand t; 4, diamond point; 5, right-hand diamond point; 6, round e; 7, finishing tool for cast iron; 8, cutting off tool; 9, threading l; 10, roughing tool; 11, tool for boring; 12, fine threading tool; right-hand bent threading tool; 14, inside threading tool.

The lathe may be fitted with various attachments that will mit it to take the place of practically any other machine tool. me of these have been previously illustrated. Many of the faces of automobile parts, especially of bearing points on shafts finished by grinding and as a regular grinding machine is expensive investment, owing to the fact that there would not enough work to keep it busy; various forms of grinding attach-nts that can be placed directly on the lathe have been devised. ose outlined at Fig. 80, may be used for either external or ernal grinding. The attachment for external grinding shown B, and C, consists of a simple stand that may be attached to tool post carriage and which supports a wheel carrying arbor d driving pulley. In order to permit the lathe carriage to be ved along the lathe bed, the attachments are driven by a long ing drum driven from the lathe countershaft and supported an independent cross shaft of its own, above the lathe bed, and a to one side of the lathe centre so the driving belt will not rfere with the work, which is usually supported by centers. tool for internal grinding is practically the same as that for ernal work except that an extension arm is provided to carry outboard bearings of the wheel spindle. These devices must very rigid as in most internal work wheels of small diameter t be used, which, of course, must be turned at high speed order to attain the recommended peripheral velocity of 5,000 to 0 feet per minute. The grinding attachment shown at D, is form that can be used in boring cylinders and similar work, that at C, would be used for external grinding on shafts pins.

iscellaneous Tools and Appliances.—The appliances shown at 81 are useful and should be *included in the* equipment of all

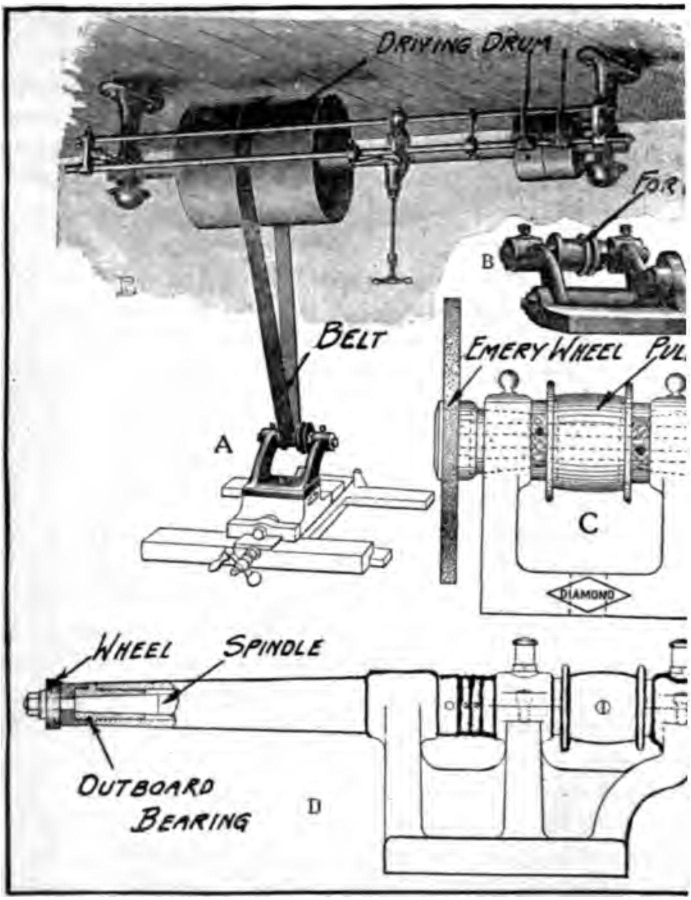


Fig. 80.—Grinding Attachments for Internal or External Work o

shops where labor-saving tools are necessary to profitable c(business. At A, is depicted a simple machine for strai bent stock, shafting, drills, reamers, drive shafts, axles, arbors, broaches and other similar components. It cons cast iron frame on which V-blocks slide, the work be ported by these, and a large screw by which pressure i *against the* bent part to straighten it. A light steel bar

front of the centers for convenience of holding chalk or pencil [illegible]en testing work that has been straightened, and adjustable [illegible]nters are provided to support the shaft at the ends when testing [illegible]r straightness. These are made in various sizes and are very [illegible]eful in reclaiming tools, stock and shafting often thrown in the [illegible]rap heap and save time and money over the common method of [illegible]mmering, centering work in lathe and testing. A moment's [illegible]rk may save a finished spindle or arbor that would be difficult [illegible] restore by use of hammer and anvil. This differs from the [illegible]m previously described in that it has a substantial cast iron base [illegible] support it, also in other minor details.

The angle-bending tool at B, is a very powerful, but simple ma[illegible]ne intended to be operated by hand for bending steel and iron [illegible] or bars to various angles without heating. The machine shown [illegible] a combination type, it can be used for light or heavy stock, [illegible]d will bend anything from light drill rod to one inch iron bars, [illegible] flat stock four inches wide by one-half inch thick or its equiva[illegible]t. Light stock is bent by swinging the dies with the hand [illegible]er, heavier material is formed by using the ratchet lever and [illegible]ion to move the dies. This is devised to be set on the top of a [illegible]ng post, which is set in the center of the floor of the shop so [illegible]t any length of stock may be bent. Various dies are furnished [illegible]d one can make U-fittings, hooks, screw-eyes and rings as well as [illegible]le pieces.

As the practise of using the softer alloys for bearings is common, [illegible]abbitt melter is a useful fixture to install in any repair shop [illegible]ng considerable overhauling work. This consists of a large [illegible]lting pot adapted to set on a bench, having a gas burner under [illegible] heat the metal. One pipe is intended for gas, the other for [illegible] air blast from blower or foot bellows. This is a much cleaner [illegible]hod of melting bearing metal than the forge fire, the coal used [illegible] containing such elements as sulphur which may change the [illegible]racter of the alloy. It is also more convenient and quicker. [illegible]t used for this purpose is shown at Fig. 81, C.

The soda kettle shown at D is used for removing grease and [illegible] from small tools, parts of automobiles, and machinery. A [illegible] f steam pipe is used to heat the solution in which the articles

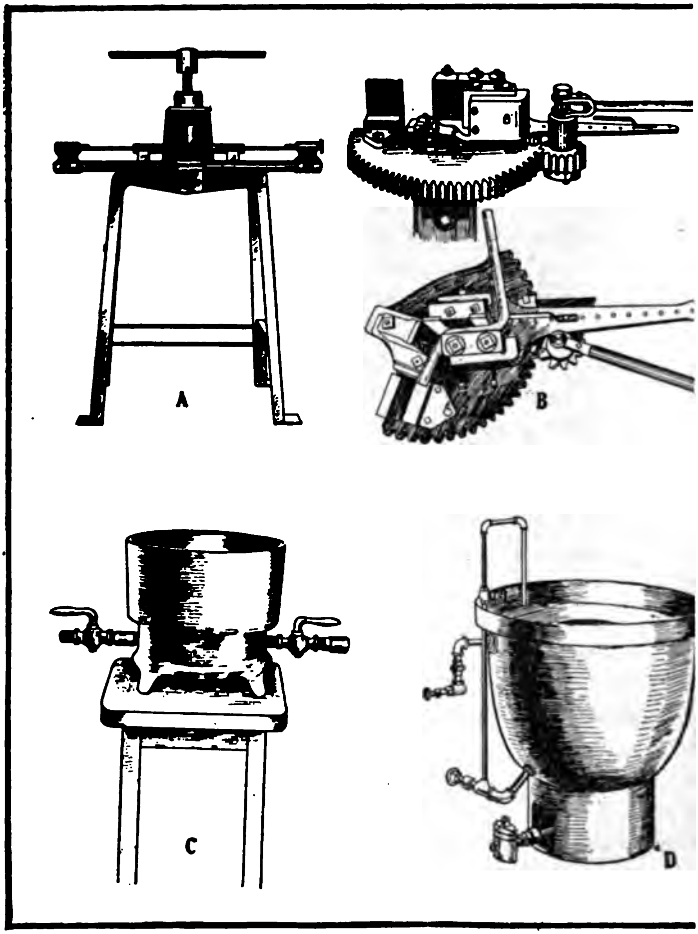


Fig. 81.—Useful Appliances to be Included in the Repair Shop Equ

are placed. This consists of washing soda and water, an immersed in the solution dry without rusting when taken ou kettles usually have a capacity of 50 or 60 gallons and tended to be placed in any convenient location among chine tools. Others are of such form that they can be *against a wall* or in a corner. A removable wire basket

r receiving the work is provided, and a small perforated bucket r shaker is furnished for washing small pieces. This method of leaning parts is superior to the common method of using gasone, as it reduces the fire risk appreciably and the soda solution nts the grease fully as well as the inflammable hydrocarbon.

It is often possible to extemporize special tools that will serve e purpose quite well by making simple additions to ordinary ols that may have outlived their usefulness and no longer be itable for the purpose for which they were primarily intended. wo useful attachments that can be easily fitted to the ordinary type monkey wrench, when the jaws have become so sprung that ey are no longer suitable for turning nuts, will permit these tools be used on pipe. These are outlined at Fig. 82, A, B, and C. at at A. is a simple pipe cutter, comprising a jaw member having recess to receive the jaw of the wrench, this being fitted with rallel arms adapted to straddle the wrench shank. A cutting eel or disc is mounted in a block sliding in and guided by a itable yoke piece. This block and the roll it carries can be moved desired by turning the handle on the feeding screw. Simple mp screws insure that the attachment will be easily and quickly ached to the wrench. The pipe is placed between the movable r of the wrench and roller, and is backed by the shank of the ench, as indicated in the illustration. This device is used in same manner as a pipe cutter, the wrench being revolved und the pipe and the pressure on the cutter block being inased gradually to cut deeper into the pipe each revolution.

The device shown at B is an extremely simple member, having ries of serrations or teeth to permit it to grip a round surface. is made of hardened steel and has a simple clip member by ich it may be easily attached to the fixed jaw of the wrench. U-shape piece is adapted to closely engage the top and sides the wrench jaw, the tooth plate is pivoted to the U-member ch a way that it will lie beneath the face of the fixed wrench . A locking member, composed of a pin having a grooved end retention spring, is passed through the U-member to hold the hment in place. Either of the attachments shown at A, or B, e fitted to a monkey wrench *without impairing* its usefulness

for the work for which it was primarily intended, as readily removable. The method of fixing a wrench : will serve as a tube or pipe cutter shown at C, means machine work is necessary, this consisting merely of small hole through each jaw of the wrench. The hard beveled edged discs used in pipe cutters can be purcha

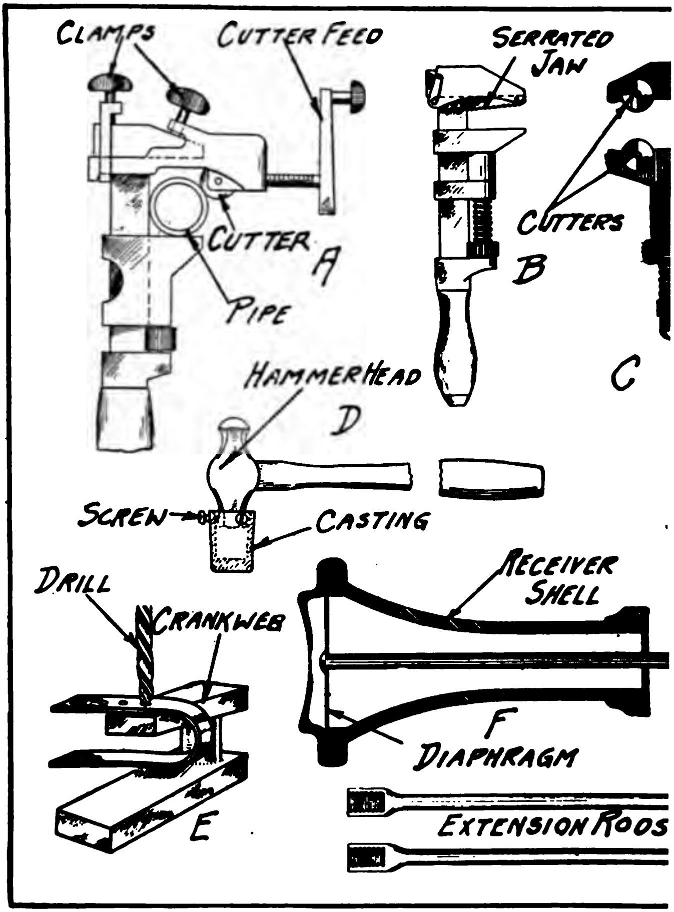


Fig. 82.—Showing Various Attachments for Use with Stand

all sum from any hardware store. The holes bored through e wrench jaws correspond to the size of that in the disc. A stove lt passed through each disc acts as a bearing and is tightened wn so the discs fit snugly against the jaws of the wrench, yet t tightly enough to prevent them from turning. Different sizes pipe may be cut by simply adjusting the jaws as would be neces-ry to fit the wrench on various size nuts.

A soft metal hammer is very useful, but in some cases it may used so seldom that the expense of buying a copper or babbitt mer would not be warranted. A simple substitute is shown Fig. 82, D. This is a copper, soft brass or babbitt casting fitted the hammer head by three screws. The pattern for the casting be easily made and can be turned out hollow, no core being essary. If lead or babbitt metal is used, the casting should somewhat heavier than if a stronger material, such as copper brass is employed.

Some types of work, such as light U-shape brackets and similar mbers are not easily drilled on account of the difficulty in holding e on the drill press. At Fig. 82, E, a method of utilizing a tion of a discarded crankshaft for making a drilling block is rly shown. The cheeks of almost all crankshafts are planed oth and parallel, thus making that portion of the shaft parti-arly suitable for this use. The journals are sawed off close each web and these are filed or milled so that the cheek will t firm and level on the drill press bed. The block shown may used for drilling all light bent work and the raised portion en-s the bent part of the work to clear during the operation of ling. A block of this nature may be easily clamped onto the l press table by a standard spring clip.

Modifications of the stethoscope employed by physicians are ed for detecting noisy operation of automobile engines, gear and other portions of the mechanism. The operation of these es, as is well known, is to localize the noise and thereby ascer-the part or parts at fault. A very good sonoscope, as these ments are called, that may easily be contrived by the repair-is shown at Fig. 82, F. This is made from an old telephone ver shell, the construction being so clear that further descrip-

tion seems unnecessary. The pieces shown below the rec are extensions by which the rod transmitting the sound tc diaphragm may be lengthened when necessary to reach inacces parts.

An adjustable socket wrench that has considerable mei shown at Fig. 83, A. This consists of a main handle T, mad square section stock with a cross bar welded to the top by v it may be turned, a piece of spring steel bent as shown and a of rectangular form riveted to the lower end of the wrench ha Owing to the tapering sides, as the handle is drawn up the are permitted to open and the space between them increases, a ing the tool for a larger nut than when the handle was pushed down and the jaws brought closer together.

Gaskets and washers of various material, such as rubber, asb or felt are widely used in automobile construction. These hard to cut by the ordinary method of using scissors or a l A washer cutter, such as shown at Fig. 83, B, forms a useful a of repair shop equipment. The cutting blade is carried by a ing support which may be set at any desired point on the gradı cutter bar. The cutter bar is turned by a large T-handle v not only provides leverage to rotate the cutter but also s the member carrying the cutter bar into the supporting arm provides a feed so the cutting tool will go through the materi which the washer is to be made.

Mention has been previously made of the desirability o cluding a soft hammer in the repairman's kit and a simple fi that can be attached to an ordinary machinist's hammer has previously described. The "Horat" soft hammer mold whi shown at Fig. 83, C, makes it possible for the repairman to his own soft hammers at relatively slight expense. The oper is extremely simple. A piece of pipe of the size that is to for the handle is inserted in the mold and the swinging top or u portion of the mold is brought in place and tightly clamped ag the pipe by a member provided for that purpose. Old babbitt or worn out bushings of white metal are placed in the ladle p of the mold and are then melted over the forge fire. Whe *metal is fluid,* the mold may be easily picked up and tilti

e molten material to flow from the ladle into that portion nold surrounding the piece of pipe. When the metal ed, a mallet head of substantial proportions will be found und the pipe handle.

of the most disagreeable of the operations incidental to g is fishing for lost bolts and nuts in the narrow confines tor crank case, gear case or in the small space between

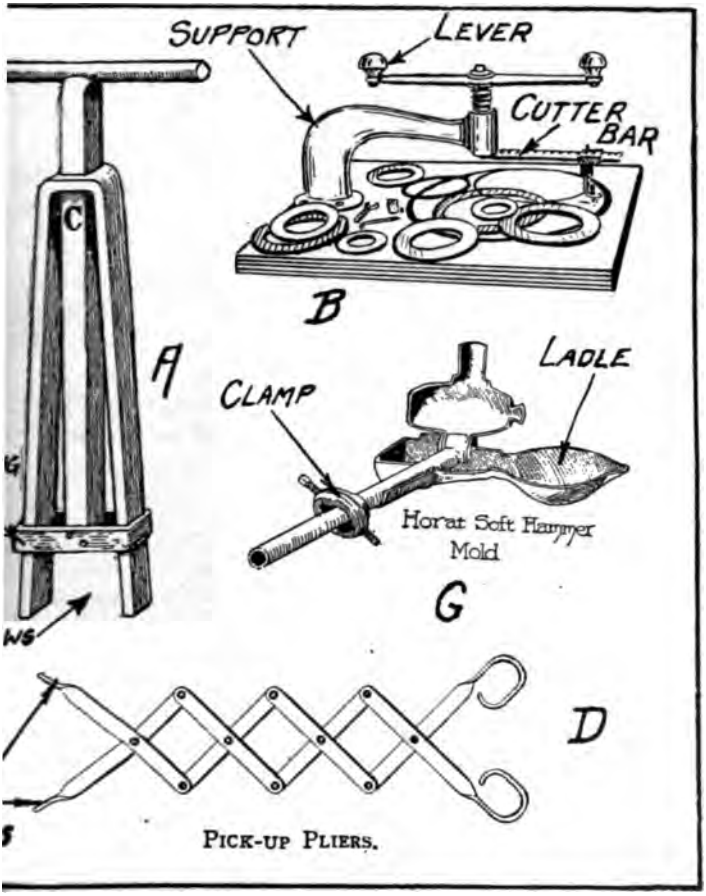


Fig. 83.—Miscellaneous ***Devices for the*** **Repair Shop.**

the engine and the under pan, where it is difficult to thr hand or arm. The usual implement for fishing out the lost is a bent wire or copper tube, but the pickup pliers built lazy tongs principle shown at Fig. 83, D, make it possible t almost any object. The pliers measure 21 inches in length, ext but when folded they are but 7 inches long.

Special Home-made Tools.—The tool outfit of most autc repairmen of experience includes many special tools tha have made from time to time for doing special jobs. Many o are well adapted for general work and some that were m the writer when he was in the repair business are shown at F and 85. While the method of construction is apparent fr sketches, it may be well to describe the uses to which the to be put. At Fig. 84, A, is shown a cotter pin tool used tracting split pins, where these are employed as a locking It will be noted that a fin of metal is provided at the hook which serves as a point of support by which considerable le may be exerted by a simple rocking motion, the fin being sup by any convenient projection adjacent to the pin to be re The other end of the tool is flattened and bent up to form a sp to expand the ends of the pin after this member has be serted in the bolt. The offset screw driver shown at B, is bent up from a heated piece of tool steel, filed to shape an hardened and tempered. These may be made in variou depending on the size of the screws they are to remove.

At C, is shown a socket wrench having a T-handle th be made to fit any odd size bolt head or nut that the regula sockets do not provide for. A bent box wrench which can b for spark plugs is shown at D. A home-made universally T-handle for turning sockets such as shown at F, is clearly o at E. At the present time these tools may be purchased f cheaply as they can be made, unless some odd size is neede cannot be bought. The socket wrench shown at G, was mad an old bit stock and was intended to fit the clamping n quick detachable demountable rims. Modifications of this to prove useful wherever there are a number of nuts of the sa *that must be* removed from time to time. The forged T-

driver shown at H, was made to handle large screws and d head bolts that could not be turned with the usual pattern ·ew driver. The wrench at I was specially devised for remov- :astellated valve chamber caps. The bars at J, and K, are useful for bending or straightening mud guard irons, step and brackets, tierods, etc. That at J, is an adjustable type, one ıe projections being movable and capable of being inserted ıy one of the holes provided on the handle. At L, is shown

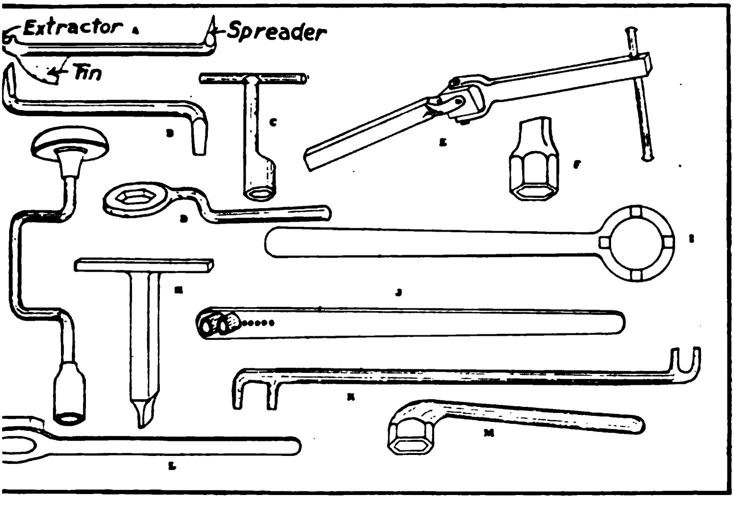


Fig. 84.—Special Tools That Simplify Automobile Repair Work.

:cial wrench made for removing the valve chamber caps hav- ın internal hexagon socket and also hub caps of the same de- The wrench at M, was made to handle cylinder head re- ng bolts that could not be reached with an ordinary monkey ch, because a wrench of the proper size was too large through aws to fit the bolt heads which were set in depressions in the der head casting.

.nother group of useful tools is shown at Fig. 85, these also ; so clearly outlined that but brief description will be necessary. two blocks A, are used *for flaring* the ends of copper or

brass tubing used in making oil or fuel leads so they wil coned end of couplings or unions. The blocks are steel, c or bronze, of the same size and held together in proper by small dowels. The holes are of proper size to handle 3 5-16, 3-8 and 7-16 inch diameter tubing respectively, and t are countersunk so the desired flare may be obtained. I these, the tube is placed in the proper sized hole, and firmly

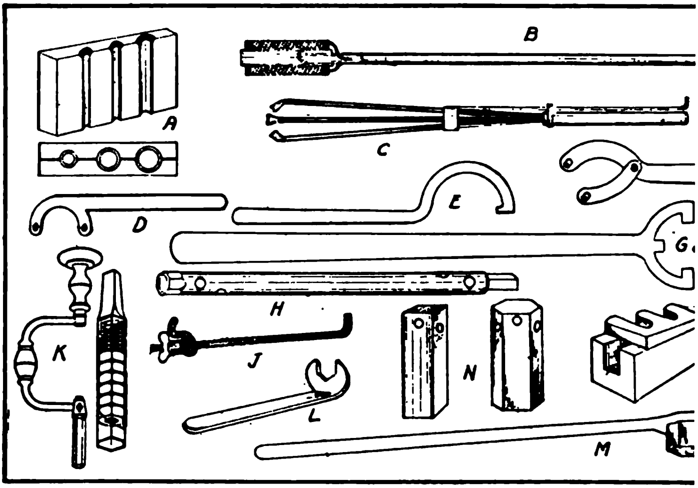


Fig. 85.—Another Group of Special Tools and Appliances of ' to Automobile Repairmen.

between the blocks in a vise. A portion of the tube p: above the surface, and is expanded by driving a taper p the tubing fits the sides of the countersink.

There is no more annoying condition that confronts th man occasionally than dropping a bolt, nut or other sm into some particularly inaccessible place such as a cranl gearcase interior from which it must be removed at any cc this reason, the utensils illustrated at Fig. 85, are of sp terest. That shown at B, is a small electro-magnet having handle so it can be thrust into very inaccessible places. Th

piece of soft iron about ½-inch diameter, having a hole bored ıe end to receive a piece of ¼-inch annealed copper tubing. 'hree layers of No. 18 magnet wire are wound around it, one end e wire being soldered to the copper handle close to the point ıncture with the iron piece. The other end of the wire is ght through the tube and is allowed to protrude for several s at the other end. A small terminal is soldered to the handle e the wire comes out. To use this, the magnet is connected six volt battery, preferably dry cells (as the resistance of the ıet winding is so low it might short circuit a storage battery), brought in contact with the nut or bolt to be removed. If is iron or steel, it will be attracted by the magnetic force held to the magnet and it can be easily withdrawn.

'nfortunately, all small parts are not of magnetic material, as such a magnet would not be of any use if the object were ı, copper or aluminum, the tool shown at B is also useful. This ıde on the principle of a fruit picker, a number of fingers being ıd together at one end and secured in a handle, while a sliding can be brought down toward the lower end to close them ı the object to be removed. The fingers are light steel rod, ened and serrated at the lower end to afford a grip on an ularly shaped piece. The sliding ring is worked by a light extending to the top of the handle where it may be easily raised depressed when the lower portion is thrust in the interior crankcase, or gear housing in search of some matter out of e. Either of these devices will be found to have many uses, the expense of making them is so slight as to be almost negli-e.

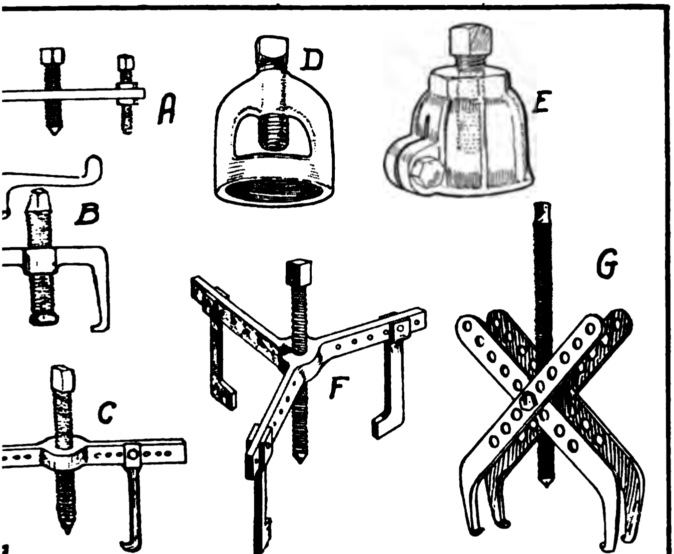
It is not always possible to provide retention or clamping nuts ing square sides to hold a wrench. In some cases this construc-ı would be objectionable on account of appearance, in others, a internal clamping nuts, it is not possible to fit either a hex ı square. Nuts of this form are usually provided with a series holes drilled in their face, if of the internal form or with milled across their periphery, if of the external form. While possible to move these with a drift pin and hammer it is al-s preferable to *use spanner wrenches for the* purpose. These

are very simple and may be easily made by any repairman. T solid form shown at D, Fig. 85, has a disadvantage of only fitti one size of nuts. The adjustable form shown at F, which ha swinging arm, may be set to handle quite a range of work. T nut is turned by small pins projecting from the face of the wre and adapted to fit into the holes in the nuts. For external n having milled slots, the wrench shown at Fig. 85, E, is used. T large spanner wrench shown at G, is utilized for removing va chamber caps provided with a castellated top. The special soc wrench is useful where bolts or nuts must be turned from a tance as in working down through a seat or floor board where ordinary wrench could not be handled.

A chain repair block is shown at I. This consists of a iron base, having a channel milled through it or cored therein fit the size of chain the block is to support. A piece of steel bo plate, a little less in thickness than the chain roll diameter having three projecting fingers is made to rest on the top of block. The function of the slots between the fingers is to prov space for supporting the rollers while the chain link sides rest the finger. This forms a secure method of holding the drive ch for driving out rivets that hold the chain links and rolls togetl It is often difficult to replace a chain on sprockets if no is available for holding the chain ends together while insert the master link. The simple tool shown at J, was made by writer in less than a quarter of an hour and proved very us for doing this work. The main portion consisted of a piece cold rolled steel rod having a hook bent up at one end and carry a wing nut and sliding hook on the other. The sliding hook simply an eye piece having a hook formed at one end. Tighter on the wing nut moved the eye piece on the shank and the e of the chain were brought together owing to the movement of hooks which filled the space between two of the rollers at each

A magazine wrench which is useful in removing a numbe nuts of the same size rapidly without necessitating handling t is shown at K. Tools of this form have been used by racing dri in making quick demountable rim changes with ease and rapid *The device consists* of a cheap bit brace and special long so

. simple clip is attached to the socket wrench, this hav- :ting pin into the interior in order to hold the nuts from ; of their own weight or by spring pressure. A coil ed back of the nuts in order to force these down against in. Assume that a rim is held by six nuts. It will t that all of the nuts may be carried in the body of the hout any trouble. To release the nut it is merely neces-



86.—**Showing Construction of Wheel and Gear Pullers.**

tch it on the thread, screw it home and then pull out the he little lock spring will move back and permit another p in place ready to be screwed onto the next retaining pring insuring constant feed. The special wrench shown ie usual form of end wrench with the jaw portion bent ngles to the handle. A wrench of this form can often here the regular type would be at a disadvantage. Men- een previously made *of valve chamber* caps that were

provided with internal hexagon or square sockets. The wre shown at M consists of a forged handle having a piece of stock of the proper section securely welded to it. The length of handle provides considerable leverage, makes it possible to rem the valve caps even if these are rusted in place. The short pi of bar stock shown at M are used for the same purpose, are intended to be turned by a large monkey wrench or by in ing a lever or pinch bar in the holes provided for the purpo the top of the bar.

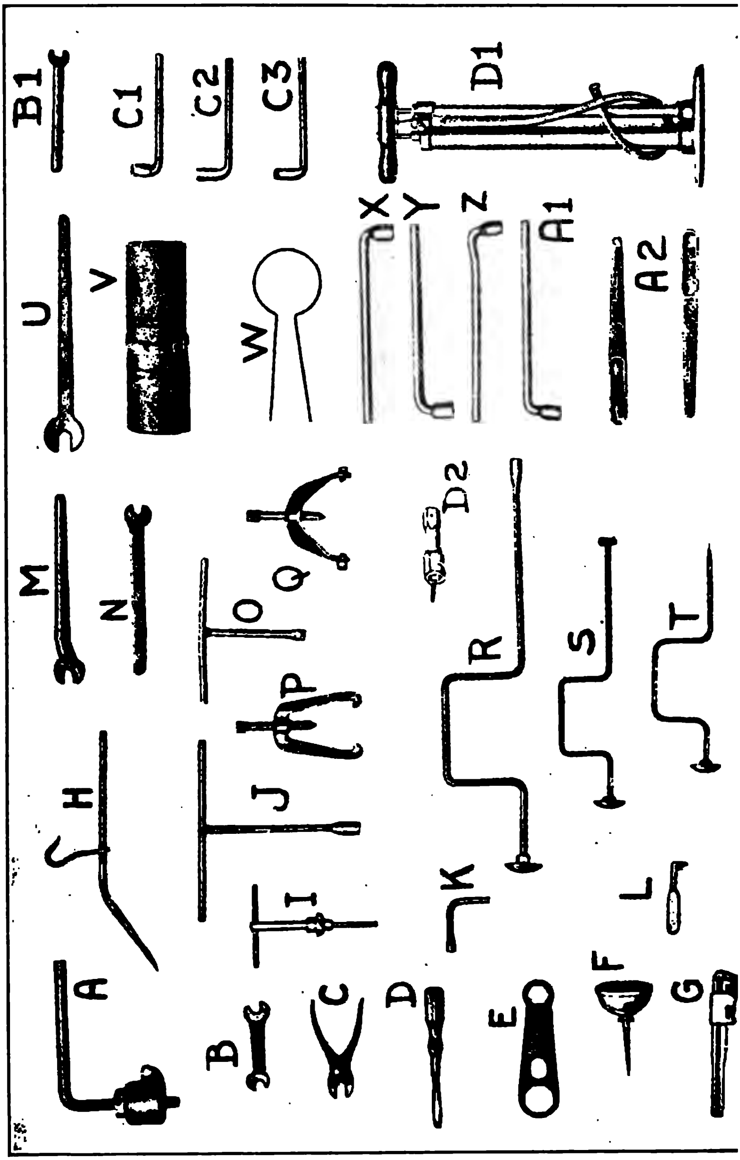
Wheel and Gear Pullers.—When wheels or gears have se on their axles, due either to want of lubrication or to grit, rust, special forms of pullers are needed to remove them without inj The form shown at Fig. 86, A, is intended to be used on gears have threaded holes in the web to receive the screws on the of the cross bar. When these screws are properly entered, p sure on the central screw will draw off the gear from the The form shown at B, is intended to be passed around the or pulley to be removed, as it has arms with hooked ends to o a purchase on the rim of the gear. The central screw is turne a crank, but in other respects its action is similar to that sh at A. A simple form of wheel puller that may be made by repairman is shown at Fig. 86, C. The crossbar is forged fr piece of scrap steel and provided with a series of holes eq spaced each side of the boss. This is drilled and tapped to re a standard 1.125 inch screw pointed at its lower end to fit int center hole left in the end of all axles or shafts that are finish turning. The arms are forgings and can be moved back and as desired on the puller beam. The upper end of the puller are provided with yokes of sufficient size to permit the bea drop in and are held in place by a through pin which can be removed to permit the arm to be changed from one hole to an according to the size of the object to be removed.

The large wheel puller shown at F, is practically the sa construction as that shown at C, except that it is more pow and has three arms instead of two. The advantage gained by construction is that the pressure is exerted at three equidi points and it is not possible for the puller to spring sideways

pressure is applied to the screw as sometimes occurs with :wo-armed form. The beam is a heavy steel forging, the arms hich are drilled with a number of holes so the hook members be moved to accommodate various sizes of work. For re- ing wheels from live axle shafts, as is necessary on all non- ing rear axles, the devices shown at D and E are useful. These practically heavier duplicates of hub caps provided with a pres- screw in the center forced in against the axle after the device rewed on the wheel hub. The body castings may be of steel or ze and even malleable or cast iron may be employed. The ler shown at E, has a minor advantage in that threads may be ght closer to the wheel hub by screwing the clamping bolt ch tightens the body portion around the thread should that aber be a trifle undersized.

The wheel puller shown at G, Fig. 86, is a new pattern capable handling a wide range of work. The arms are heat-treated steel forgings and can be quickly adjusted to handle work as wide thirteen inches. For small pieces such as pinions, cams, etc., of inches diameter or less, extension arms are provided to enable to exert pressure for the removal of the small piece. The ter screw passes through a threaded block into which the bolts ding the arms in place screw. As each arm is provided with holes and as they are capable of swinging on the fulcrum-end will be evident that a large variety of work can be handled with wheel puller.

Typical Special Tool Equipment.—The makers of all the popu- cars, especially those that are produced in any quantity, furnish cial tools for the use of their repairmen or for those employed the service stations of the agents. As an example of the special ls that it is possible to obtain, the assortment used by repairmen Ford Model T cars is shown at Fig. 87. The device at A is a el puller designed to go on the hub in place of the hub cap. operation it is the same as the form shown at Fig. 86, D and E. tools shown at Fig. 87, B, C, D, F, G, and D-2, form part the regular tool equipment. The box wrench at E is also fur- ed with each car and is a hub cap wrench having one end ed to fit the slabbed portion *of the front* wheel bearing


A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
Q
R
S
T
U
V
W
X
Y
Z
A1
A2
B1
C1
C2
C3
D1
D2

sting cone lock nut. A valve spring lifter is shown at H, while lve seat reamer is shown at I. The valves are turned while ling by the special brace S, which can be used on all of the s except the one on the rear cylinder, which is immediately r the dash board. To turn this valve the special wrench shown , is provided. A special T-handle socket wrench for handling ich nuts or bolt heads such as used on the rear construction various other points is shown at J. A T-handle screw-driver, the set screws which are employed in retaining the camshaft ings, is shown at O. The puller shown at E is for removing am gear from the camshaft, while that at Q is a transmission h puller. The brace shown at R, is a special socket wrench ⅜-inch bolt nuts. The brace shown at T, is employed for re- ng the magnet-retaining screws in the magneto assembly. The rons at A-2, the tool roll at B, the pump at D-1, and the spark socket wrench at D-2 are all parts of the regular tool equip- furnished with each car.

he simple fitting shown at W, is a piston ring compressor oyed to compress the rings in the piston grooves to facilitate assembly in the cylinder block. A number of special socket ches are shown at X, Y, Z; A-1, C-1, C-2 and C-3. These are ntended for use on the various fastenings used in holding arts together. For example, that at X is a socket wrench for rankshaft main bearing bolt nuts. That at Y is for ⅜-inch heads or nuts. The wrench at Z is for removing the cylinder retaining bolts. The wrench for removing the pinion drive housing retaining stud nuts is shown at C-1, this being used ⅜-inch nuts. The rear axle housing bolt nut wrench is shown -2, while the form outlined at C-3 is similar to that shown -1 except that it fits 11/32-inch nuts. The special end wrench I, is for the flywheel retention cap screws, that at U, is for wing the large cam gear lock nut while that at B-1 is a regular end wrench for ⅜-inch nuts. The prices on these tools are w that it is cheaper to purchase from the factory than to at- pt to make them.

Tools and Supplies Itemized.—The following lists are presented guide for the novice repairman or motorist who wishes to make

his own repairs and enumerate the most important of the too! essary in automobile repairing and the supplies most gen used in restoring defective mechanism. It is not possible to en ate all tools that can be used to advantage as their num legion. However, selections of those needed can be made fro lists for the regular tool equipment and can be augment conditions dictate. The wider the range of work the shop attempt, the more complete the tool and supply stock mu

TOOLS FOR THE REPAIR SHOP.

Hammers:

Blacksmith's hammer—4½ lb. head.
Blacksmith's sledge—10 lb. head, short handle.
Blacksmith's sledge—20 lb. head, long handle.
Machinist's ball pein hammers—1 lb. head, 2 lb. head.
Machinist's ball pein hammers—½ lb. head.
Machinist's straight pein hammers—4 oz. head.
Wooden or Rawhide Mallet.
Lead or Babbitt hammer.

Wrenches:

Ratchet Handle Socket Wrench Set.
Six-inch Stillson wrench.
Twelve-inch Stillson wrench.
Eighteen-inch Stillson wrench.
Six-inch Coes or other monkey wrench.
Twelve-inch Coes or other monkey wrench.
Eighteen-inch Coes or other monkey wrench.
Set of double end S wrenches.
Assorted Spanner wrenches.
Bicycle wrench, small 4 inches.
Narrow jaw monkey wrench, 8 inches.
Bemis and Call Adjustable end wrench, 6 inches.
Bemis and Call Adjustable end wrench, 8 inches.
Spark plug socket wrench.
Small hand vise.

Pliers, etc.:

Combination pliers, 6 inches, 10 inches.
Side cutting, parallel jaw pliers.

...s, etc.—*Continued:*

Special anti-skid chain pliers.
Tire casing cut repair piiers.
Cotter pin-pliers.
Piston ring expanding pliers.
Tinner's snips.
Heavy shears.
Bolt cutter.

...w Drivers:

Jeweler's small screw driver.
Six-inch screw driver, ¼-inch width blade.
Ten-inch screw driver, ⅜-inch width blade.
Twelve-inch screw driver, ½-inch blade.
T handle "Bulldog" screw driver.

...cellaneous Tools:

Wheel pullers, valve spring lifters, etc.
Breast drill, two-speed.
Valve seat reamers, valve head truing cutters.
Hand drill, one-speed.
Belt punch.
Bit brace, ratchet and bits.
Carpenter's cross cut saw.
Hacksaw frame and extra saws for tubing and bar stock.
Ratchet drill set.
Gasoline blow torch.
Spring winder, chassis spring spreader.
Scrapers (carbon).
Scrapers (bearing).
Jack plane and wood chisels.
Set of number drills.
Wire scratch brush, putty knife.
Set of taps and dies—S. A. E. standard.
Set of taps and dies—metric standards (foreign).
Set of taps and dies—American standard.
Soldering irons—large, medium and small.
Set of straight and taper hand reamers.

...s, etc.:

Twelve-inch bastard cut, flat.
...welve-inch *bastard cut, half round.*

FILES, ETC.—*Continued:*

Ten-inch bastard cut, round.
Ten-inch bastard cut, square.
Ten-inch bastard cut, three-cornered.
Eight-inch second cut, flat.
Eight-inch second cut, half round.
Eight-inch finishing cut, flat.
Eight-inch finishing cut, half round.
Eight-inch finishing cut, rat tail.
Eight-inch finishing cut, three-cornered.
Six-inch finishing cut, flat.
Six-inch finishing cut, rat tail.
Set of file handles and file brush.
Small and large oil stones.

CHISELS, ETC.:

Cape chisels—small, medium and large.
Chipping chisels—small, medium and large.
Round nose chisels—small, medium and large.
Diamond point chisels—small, medium and large.
Center punches—small, medium and large.
Drift pins—1/16, 1/8, 3/16, 1/4, 5/16, 3/8, 1/2, 5/8 and 3/4-inch point.
Cotter pin puller.
Set of straight and offset scribers.

MEASURING TOOLS:

Carpenter's and machinist's tri-squares—small six-inch, large 1
four inch.
Machinist's twelve-inch flexible scale, six-inch scale, 2-inch scal
Carpenter's two-foot folding rule.
Caliper rule.
Combination square and protractor, 18-inch scale.
Spirit level, cross level.
External micrometers, one, two, three and 6-inch with extension
Internal micrometer, with extension pieces.
Thread gauge.
Hermaphrodite calipers—small, medium and large.
Small internal calipers.
Large internal calipers.
Small external calipers.
Large external calipers.
Spring dividers, small and medium.
Friction joint dividers, large.

List of Tools and Supplies

BENCH EQUIPMENT:

Medium size pipe vise.
Large swivel vise.
Medium swivel vise.
Surface plate.
Small bench anvil.
Machinist's clamps.
C clamps—large, medium and small.
Straight edge and surface gauge.
Pyrene fire extinguisher.
Angle bender.

ELECTRICAL EQUIPMENT

Extension lamps with wood handle and steel cage.
Electric breast drill.
Storage battery charging means; Rheostat, lamps or recti
Still for making pure water.
Voltmeter for testing storage batteries.
Ammeter for testing dry cells.
Hydrometers and hydrometer syringes.
Acid bottles and electrolyte crocks.
Extra strap connections, wing nuts and lead bolts.
Torch for lead burning.

TIRE REPAIR MATERIAL

Vulcanizer for casings.
Molds for same.
Vulcanizer for tubes.
Acid cure or cold vulcanizing set.
Stock outfit for vulcanizing and patching, rubber, canvas,
Rubber cements, cut fillers, etc.
Air-compressor outfit.
Jacks, two of each size, large, medium.
Tire irons, special rim tools.
Valve tools, air pressure gauge.
Extra valves and valve parts.
Casing air bags or coil springs for use when vulcanizing.
Inner tube patches, inside and outside casing blowout sleev

REPAIR SHOP FURNITURE

Movable and wall benches.
Wheeled trucks, special jacks, trestles, etc.
Oil separator and filter.
Sixty-gallon oil tanks, with pumps.
Small tanks for kerosene, alcohol, cutting oil, etc.
Gasoline storage system, 100 gallons or larger.
Oil cans, oil and grease guns.
Covered cans for waste, oily rags, and rubbish.
Pails of sand and chemical extinguishers for fire.
Overhead washer, hose and faucets.
Washing materials, soaps, sponges, chamois, etc.
Water heater.
Potash kettle, babbitt melting pot.
Drains, traps, etc., according to law.
Lightstand for night work on cars.
Block and tackle, chain hoists, etc.
Overhead trolley track or portable crane.
Turntable or substitute.
Steel or wooden lockers.
Oil drip pans for floors.
Dustbrush, floor broom, whisk broom.
Water pails, quart and gallon measures, funnels.
Brazing forge.
Autogenous welding outfit.
Carbon-removing outfit.
Blacksmith's forge and blower.
Post drill press and drills.
Five hundred pound anvil and block.
Quenching tank, forge coal box.

REPAIR SHOP SUPPLIES

Class A—Hardware Stock.

Round cold-rolled steel rods, $\frac{1}{4}$, $\frac{5}{16}$, $\frac{3}{8}$, $\frac{1}{2}$ inch.
Round machinery steel bars, $\frac{5}{8}$, $\frac{3}{4}$, $\frac{7}{8}$, 1, $1\frac{1}{4}$ inch.
Flat band iron and steel, assorted sizes as needed.
Drill rod, assorted sizes.
Black sheet iron, sheet brass and copper, assorted gauges.
Tinned and galvanized iron sheets.
Tool steel, for lathe and planer tools.

A—Hardware Stock—*Continued:*

itock in bars, ¼, 5/16, ⅜, ½-inch square.
thin copper or brass for shims.
bronze bars, for bushings, assorted.
tt or Magnolia metal ingots.
copper and iron wire, 14, 16, 18, 20 gauge.
and phosphor bronze wire, for springs.
wire solder; half and half solder; hard solder.
ag spelter, granulated and in wire.
ess steel tubing, sizes as needed.
and copper tubing, sizes as needed.
ded seamless copper tubing for fuel and gas lines—¼, 5/16, ⅜ inch.
ression couplings for copper tubing, ells, tees, unions, etc.
ly iron and copper rivets and burrs, assorted.
ed iron washers—⅛, 3/16, ¼, 5/16, ⅜, 7/16, ½-inch holes.
and nuts, assortment of standard sizes.
pins and lock washers, assortment.
rews, stove bolts, carriage bolts, assortment.
screws, round, flat and oval head, blued steel, brass and nickel.
crews, brads, nails, escutcheon pins, upholsterer's tacks.
rews, taper pins, lock nuts, assortment.
uff keys and cutters, assortment.
h brass pipe, other sizes as needed.
ard brass fittings, ⅛-inch pipe size, ells, tees, unions, pet cocks, etc.

Class B—Miscellaneous Supplies.

r, three grades—fine, medium and coarse.
, grindstone dust, ground glass, corborundum.
cloth, emery cloth, sand paper, assortment.
oil for cutting, cutting compound.
cants: cylinder oil—light medium, heavy.
cants: machine oil, three-in-one, cup grease, graphite.
cants: special grease for transmissions and ball bearings.
er matting and linoleum for floor boards, etc.
molding, for running boards, etc.
felt, assortment felt oil retaining washers.
tubes and rods, as needed.
hard rubber, black or red fiber, assorted thicknesses.
y brown paper and light cardboard for packings.
asbestos, mobiline, for packings.
rubber packings for water joints and pump covers.
tos cord, candle wicking, hemp *packing.*
ubber tu*bing for gas line, 3/16, 5/16-inch hole.*

CLASS B—MISCELLANEOUS SUPPLIES—*Continued:*

Rubber steam hose for water connections.
Assorted hose clamps.
Assorted copper-asbestos gaskets and packings for popular cars.
Spark plugs, ½-inch Briggs pipe, metric and S. A. E. standard.
Dry batteries, 6 x 2½ inch, and connecters.
Aluminum solder and flux.
Sheet celluloid for top windows.
Primary and secondary cables, terminals, etc.
Circular loom, electrical tape, insulating varnish.
Round and flat leather belts and lacings.
Coil spring fan and oiler belts, couplings.
Spring clips, oil and grease cups, compression relief cocks.
Waste and cleaning cloths.

CLASS C—CHEMICALS, PAINTS, ETC.

Carbon tetrachloride, benzine, rust remover.
Grain alcohol, white and orange shellac.
Body polish, metal polish, varnish, black enamel.
Black asphaltum paint, stove polish, exhaust pipe black.
Pearl gray cylinder enamel, other colors as needed.
Aluminum powder and banana oil lacquer.
Rubber cements, smooth-on for metal, glue for wood.
Talcum powder, borax, fuller's earth.
Putty, fire clay, asbestos cement.
Kerosene, wood alcohol, gasoline, acetone.
Paraffine wax, beeswax, tallow, resin.
Proprietary welding, brazing and soldering fluxes.
Calcium chloride and glycerine, for anti-freeze compounds.
Wood alcohol, for anti-freeze compounds.
Potash or lye, sal-ammoniac, washing soda.
Muriatic acid (soldering fluid), hydrofluoric acid (for marking tools).
Copper sulphate solution for coppering steel or iron before marking.
Sulphuric acid (chemically pure) and distilled water.

CHAPTER III.

OVERHAULING THE GASOLINE ENGINE

aking Down the Motor—Examination and Marking of Parts—Defects in Cylinders—Carbon Deposits, their Cause and Prevention—Use of Carbon Scrapers—Denatured Alcohol—Burning Out Carbon with Oxygen—How Oxygen is Produced—Repairing Scored Cylinders—How to Repair Cracked Water Jacket—Inspecting Cylinder Packings—Valve Removal and Inspection—Reseating and Truing Valves—Valve Grinding Processes—Depreciation in Valve Operating System—Piston Troubles—Removing Piston Stuck in Combustion Chamber—Piston Ring Removal and Inspection—Fitting Piston Rings—How Wristpins are Held—Wristpin Wear—Inspection and Refitting of Engine Bearings—Adjusting Main Bearings—Crankpin Restoration—Scraping Brasses to Fit—Connecting Rod Bearings—Testing Bearing Parallelism—Ball Bearing Crankshafts—Camshafts and Timing Gears—Valve Timing Methods—Sleeve Valve Motors—Eight-Cylinder V Motors—Precautions in Reassembling Parts—Loose Flywheels—Two-Cycle Motors.

Many car owners recognize the value of having the car overhauled before the inception of the active riding season when climatic conditions are not favorable to the continual operation of the car. In those portions of the country where cars may be kept in operation all the year round, a certain time each year should be set apart for giving the car a thorough looking over with a view of determining the points where depreciation exists, and the best methods of remedying the defective condition. The wise motorist realizes that this work of restoration is absolutely necessary, if continued satisfactory service is to be expected from the car. The motorist who shuns the expense of having the machine looked over and who operates it as long as the various parts function, is generally the one who is loudest in the condemnation of the automobile. In this chapter, the writer proposes to discuss the various steps incidental to overhauling gasoline engines of various types

and in order to do this in a way that will be of value to the motorist or novice repairmen it is necessary to treat of the various part in logical sequence. The suggestions given are all based on a practical experience with the repair of automobiles and nothing o doubtful value will be described.

Taking Down the Motor.—In order to look over the part of an engine and to restore the worn or defective components it i necessary to take the engine entirely apart as it is only when th power plant is thoroughly dismantled that the parts can be inspected or measured to determine defects or wear. If one is no familiar with the engine to be inspected, even though the wor is done by a repairman of experience, it will be found of valu to take certain precautions when dismantling the engine in orde to insure that all parts will be replaced in the same position the occupied before removal. There are a number of ways of identifying the parts, one of the simplest and surest being to mark the with steel numbers or letters or with a series of center punch mark in order to retain the proper relation when reassembling. Thi is of special importance in connection with dismantling multipl cylinder engines as it is vital that pistons, piston rings, connectin rods, valves, and other cylinder parts be always replaced in th same cylinder from which they were removed, because it is uncommon to find equal depreciation in all cylinders. Some repairme use small shipping tags to identify the pieces. This can be criticize because the tags may become detached and lost and the identity o the piece mistaken. If the repairing is being done in a shop wher other cars of the same make are being worked on, the repairma should be provided with a large chest fitted with a lock and ke in which all of the smaller parts, such as rods, bolts and nut valves, gears, valve springs, camshafts, etc., may be stored to prevent the possibility of confusion with similar members of othe cars. All parts should be thoroughly cleaned with gasoline o in the potash kettle as removed, and wiped clean and dry. Thi is necessary to show wear which will be evidenced by easily identified indications in cases where the machine has been used for time, but in others, the deterioration can only be detected by delicate measuring instruments.

typical four cylinder automobile motor is shown at Fig. 88, all parts in place. In taking down a motor the smaller parts fittings such as spark plugs, manifolds and wiring should be ved first. Then the more important members such as cylinders be removed from the crankcase to give access to the interior

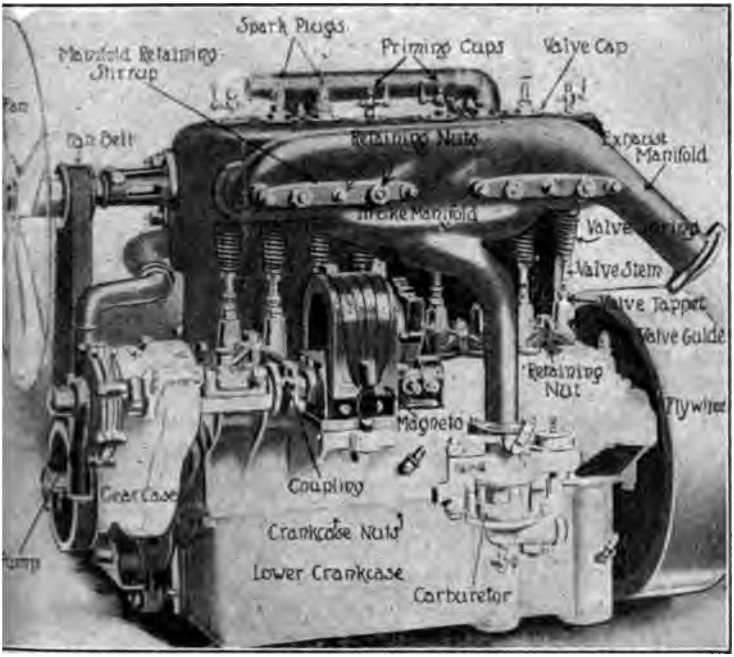
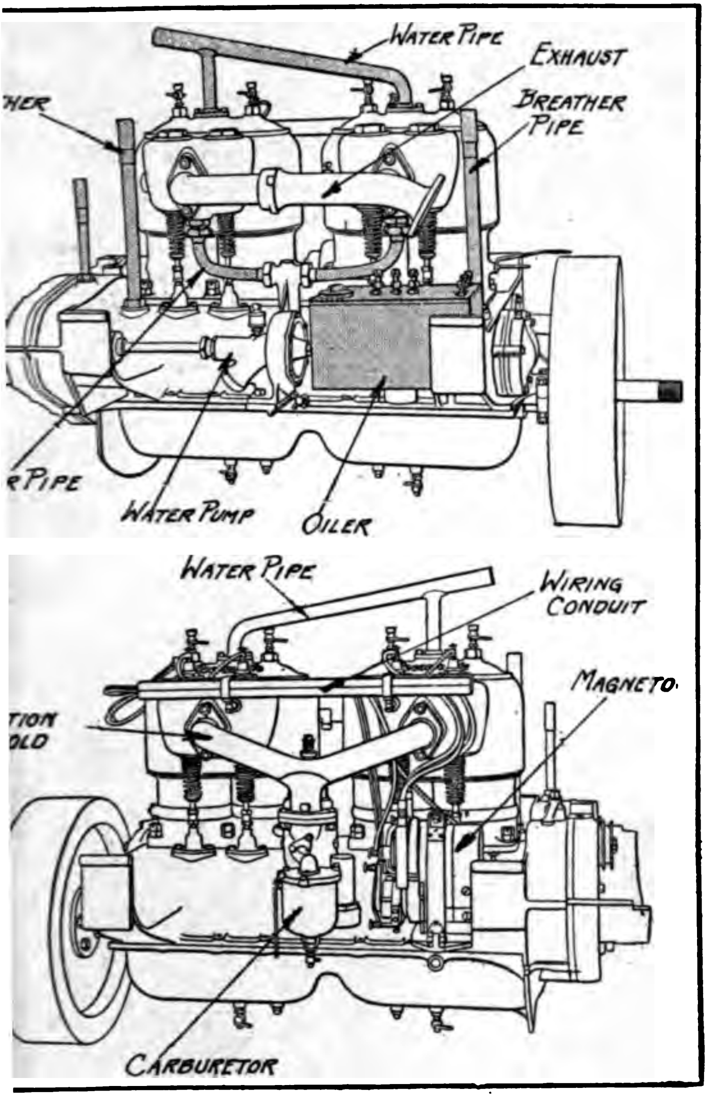


Fig. 88.—View of Typical Four Cylinder Automobile Power Plant.

make possible the examination of the pistons, rings and conting rods. After the cylinders are removed the next operation o disconnect the connecting rods from the crankshaft and to move them and the pistons attached as a unit. Then the crank- is dismembered, in most cases by removing the bottom plate, s exposing the main bearings and crankshaft. The first opera- is the removal of the inlet and exhaust manifolds, next one ouples the water piping from the *radiator*. There are various

methods of fastening manifolds on the cylinder casting, the common being by retaining stirrups as shown in engine at 88, or by flanges and bolts as outlined in illustrations of er at Fig. 89. As will be evident, where cylinders are of the T form with valves on opposite sides of the cylinder casting bolt and flange system is generally used. On L-head motors, the valves are in the same extension of the cylinder casting bolt and stirrup retention method is generally followed. One safely say that engines of low and moderate priced cars, bei the L-head form will have the manifold retained by stirrup bolts, whereas the T-head power plant of the larger and h priced cars will use the bolted manifold construction.

It is now common practice to cast all cylinders together, t of four being very common and blocks of six are not rare en to cause comment. In some cases the manifolds are cored int with the cylinder casting and it is merely necessary to re a short pipe leading from the carburetor to one inlet opening the exhaust pipe from the outlet opening common to all cylin In order to remove the carburetor it is necessary to shu the gasoline supply at the tank and to remove the pipe cou at the float chamber. It is also necessary to disconnect the thı operating rod. After the cylinders are removed and before t the crankcase apart it is well to remove the water pump, mag and mechanical oiler if that system of lubrication is used. wiring on most engines of modern development is carried in duits and usually releasing two or three minor fastenings permit one to take off the plug wiring as a unit. The wire shou disconnected from both spark plugs and magneto distributo fore its removal. The appearance of the engine shown at bottom of Fig. 89, after the magneto ignition wiring, spark] and front of timing gear case are removed is shown at Fig. 9 The next operation in dismantling this engine is to take of four nuts holding the induction manifold to the cylinder cas and when the manifold is removed the carburetor comes wit The appearance of the engine after this has been done is s at Fig. 91, B. The next parts to be taken off, the cylinder cast *are shown* shaded in this view. The appearance of this engine



—Exhaust and Intake Sides of Locomobile Four Cylinder Motor.

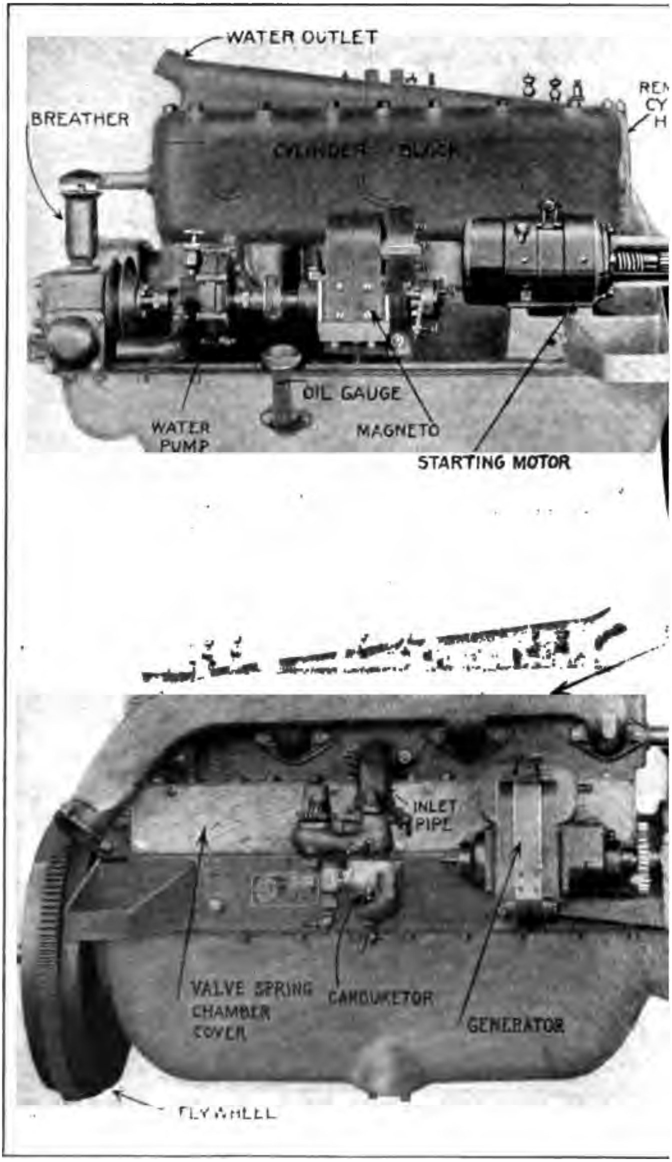


Fig. 90.—Views of **Overland Model 82 Six Cylinder Motor. Typical Block Motor Design.**

the cylinders have been removed is clearly indicated at Fig. 9: In this case the magneto or water pump has not been disturbe‹ The pistons, piston rings, and connecting rods are clearly expose and their condition may be readily noticed.

Before disturbing the arrangement of the timing gears, it : important that these be marked so that they will be replaced i exactly the same relation as intended by the engine designer.] the gears are properly marked the valve timing and magneto se ting will be undisturbed when the parts are replaced after ove hauling. When an engine has been taken down to the point show at Fig. 92, it is possible to ascertain if there is any undue wea present in the connecting rod bearings at either the wrist pin c crank pin ends and also to form some idea of the amount of carbo deposits on the piston top and back of the piston rings. Any wea of the timing gears can also be determined. The removal of th bottom plate of the engine enables the repairman to see if th main bearings are worn unduly. Often bearings may be taken u sufficiently to eliminate all looseness. In other cases they may b worn enough so that careful refitting will be necessary.

All engines are not of the type shown at Figs. 88 and 89. Wher the crankcase is divided horizontally into two portions, the uppe one serving as an engine base to which the cylinders and in fa all important working parts are attached, the lower portion, pe forms the functions of an oil container and cover for the intern mechanism. There is a tendency on the part of modern designe to combine the cylinders and a portion of the crankcase in on casting, using a detachable cylinder head construction in order t permit valve grinding and carbon removal without taking the engin out of the chassis frame. The connecting rods and pistons ma also be removed where this construction is followed through th opening left after the detachable cylinder head is removed. I the engine shown at Fig. 93, not only the cylinders but practicall the entire engine crankcase, except for the plate closing the bo tom is cast in one unit. It will be evident that the removal o the bottom plate and cylinder head will provide access to th interior of the motor. Attention is directed to the inlet manifol construction which is cored in the cylinder block. The exhau

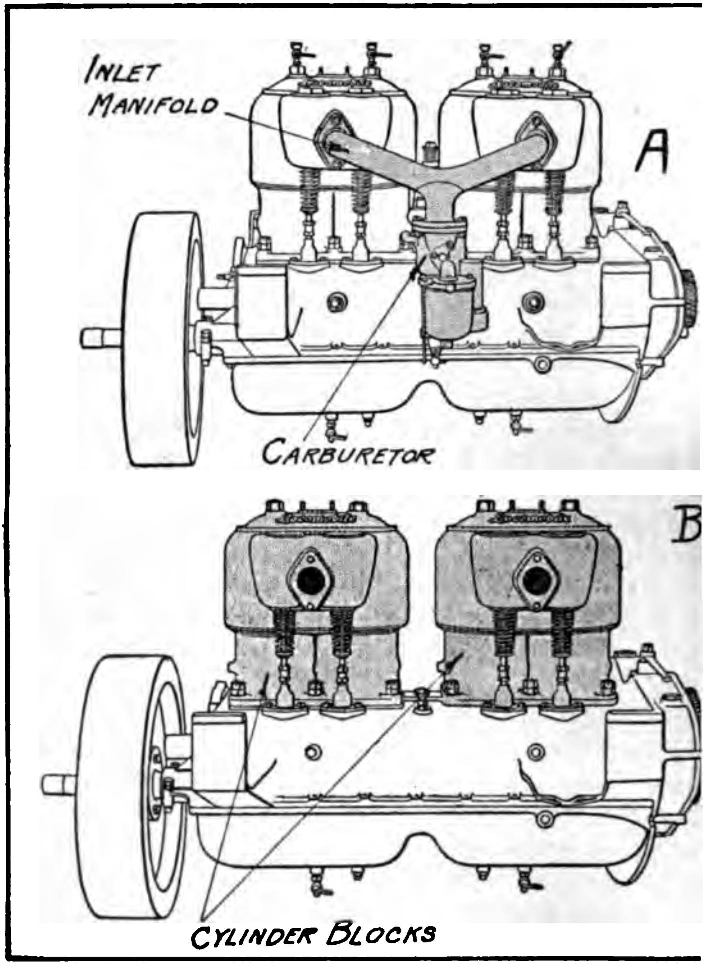
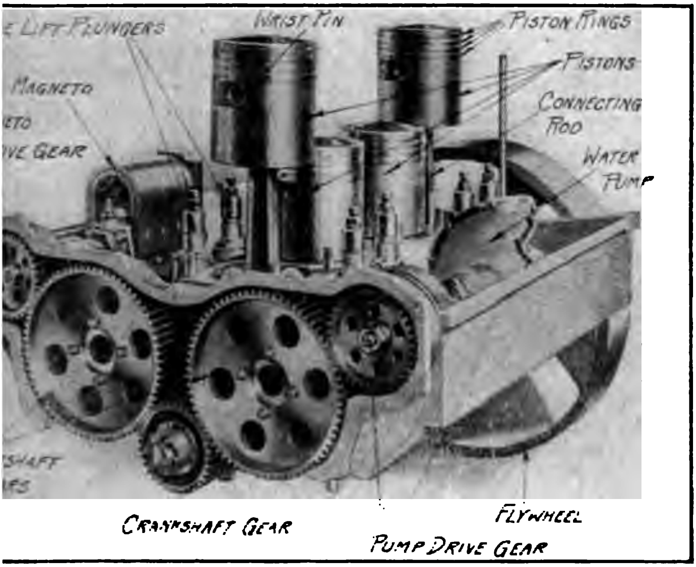


Fig. 91.—Illustrating Steps in Removing Motor Parts when Dism[illegible] Power Plant.

manifold however, is a separate casting secured to the c block in the usual way.

The important parts of an engine of the convention[illegible] *cylinder pattern* where the cylinders are cast in pairs are

ıt Fig. 94, and their appearance may be readily noted. ıe evident that when the bottom of the crankcase is removed ıkshaft is exposed and the main bearing caps may be re- ıy unscrewing the bearing cap retention bolts. A number s of typical engines are also indicated at Fig. 95. The A, shows the appearance of the usual arrangement of the



—View of Automobile Engine with Cylinders Removed to Expose ons and Connecting Rod and with Timing Gear Case Taken Off Expose Gearing.

gears when cylinders of the T-head form are employed. be apparent one large gear is carried by each camshaft, ng turned by a pinion of half their size on the crankshaft. hod of retaining the timing gear varies with the con- ı of the engine. In the form shown at A, the gears are the flanged camshaft end by three square head cap screws re wired together to prevent loosening. In the construc- rn at Fig. 92, the *camshaft gears are securely* held by four

castellated retention nuts which screw on studs projectir the camshaft flange end. The smaller gears, such as the ı drive and pump drive are usually held by a key which is a taper shaft and the gears are tightly clamped on the t: substantial clamping nuts.

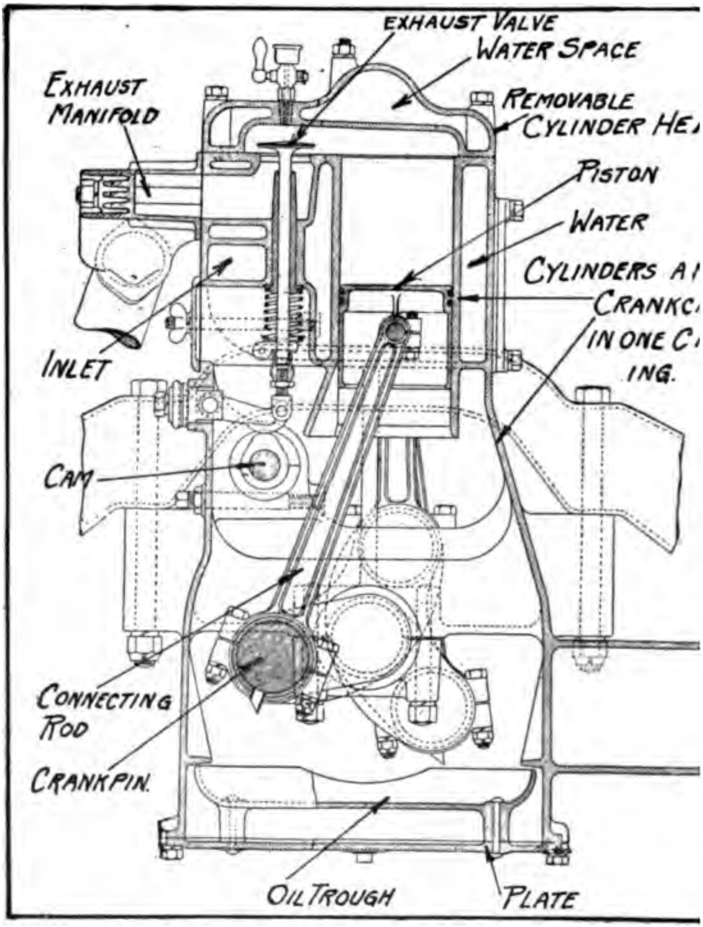


Fig. 93.—End Sectional View of Lewis Six Cylinder Motor S Unconventional Construction in Which Cylinders and Cran are Formed Integral.

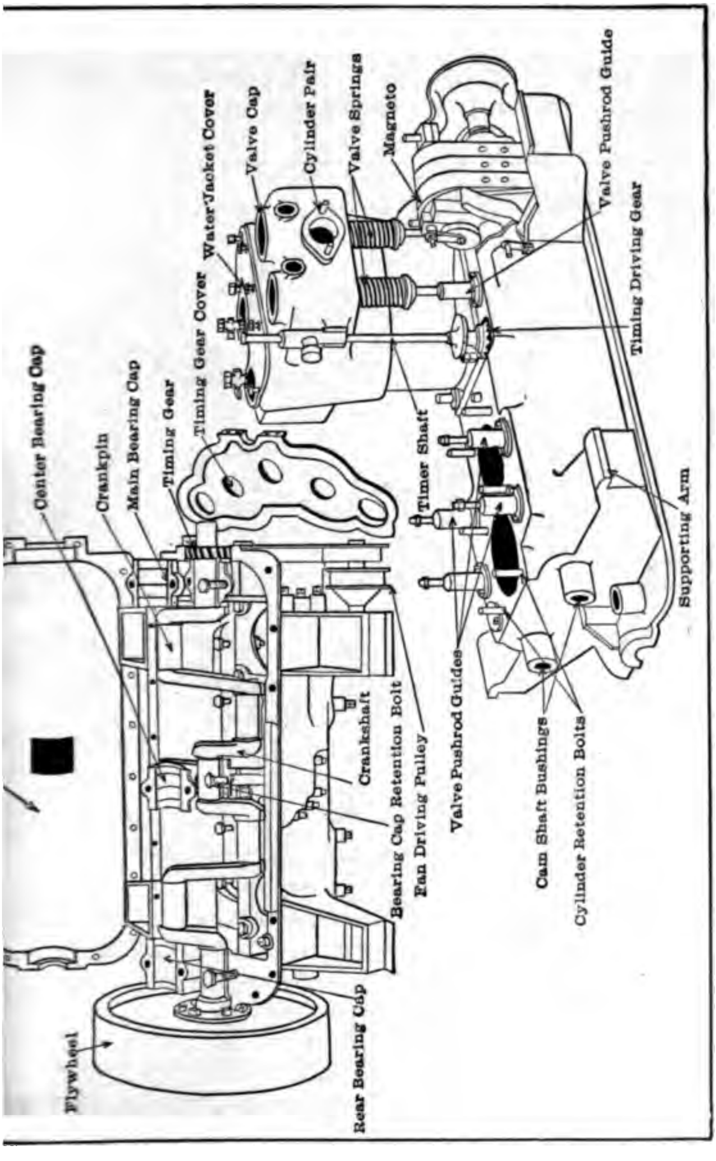


Fig. 94.—Views of Partially Dismantled Automobile Engine.

Attention has been previously called to the necessity of ing the timing gears. The manner in which this can be clearly indicated at Fig. 95, B. It will be seen that the shaft gear is provided with two figures, "1" and "1," oppos

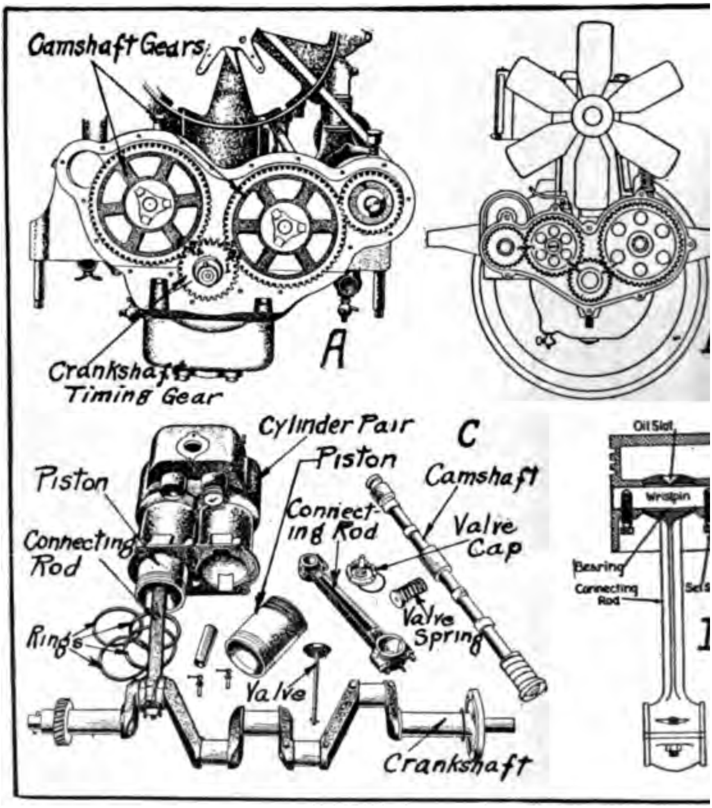
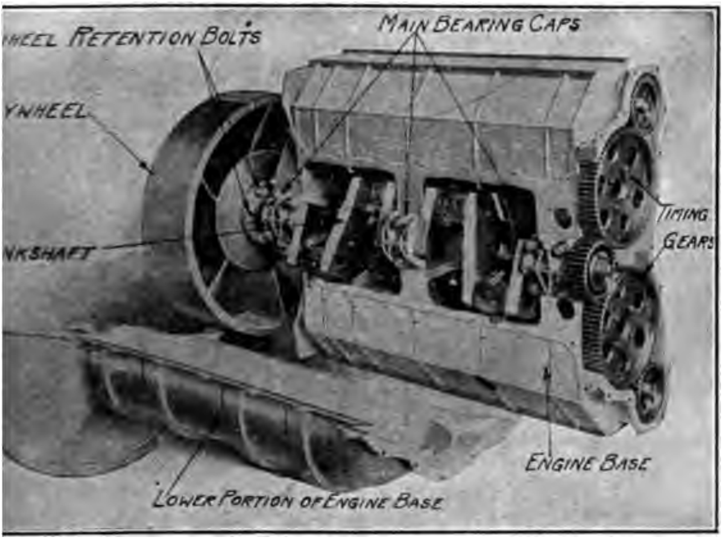


Fig. 95.—Showing Method of Marking Timing Gears and Gr Miscellaneous Motor Parts.

tain teeth. The camshaft drive gear is provided with a nu to indicate the space that the tooth marked 1 on the cranksh should occupy. Similarly the intermediate gear which tr *motion* to the magneto drive gear is marked with a 2 and

correspond to the corresponding numerals on the crank-
ear and member driving the magneto armature. At C,
, is shown a group of the important internal parts of the
These are plainly marked and should be readily recognized
the novice. At Fig. 95, D, a typical piston and connecting
embly is depicted. In this view, the parts are also identified
rther description is unnecessary.



6.—Lower Portion of Engine Base Removed to Show Crankshaft and Accessibility of Main Bearings.

e illustration at Fig. 96, is that of the crankcase shown at
2, as it looks when viewed from the bottom after the lower
n of the crankcase has been removed. As will be apparent,
ain bearing caps that hold the crankshaft in place may
eased by taking off the retention nuts and the connecting
aring caps which keep these members attached to the crank
re also exposed for inspection.

some multiple cylinder engines the cylinders are cast indi-
lly and instead of the crankshaft having three main bearings,

as in the engine shown at Fig. 96, it has five main bearin indicated in the sectional view of the Overland engine s at Fig. 97. When the cylinders are cast individually it is po to replace a defective cylinder without sacrificing the remaind is imperative if the cylinders are cast in block. Individual cyli

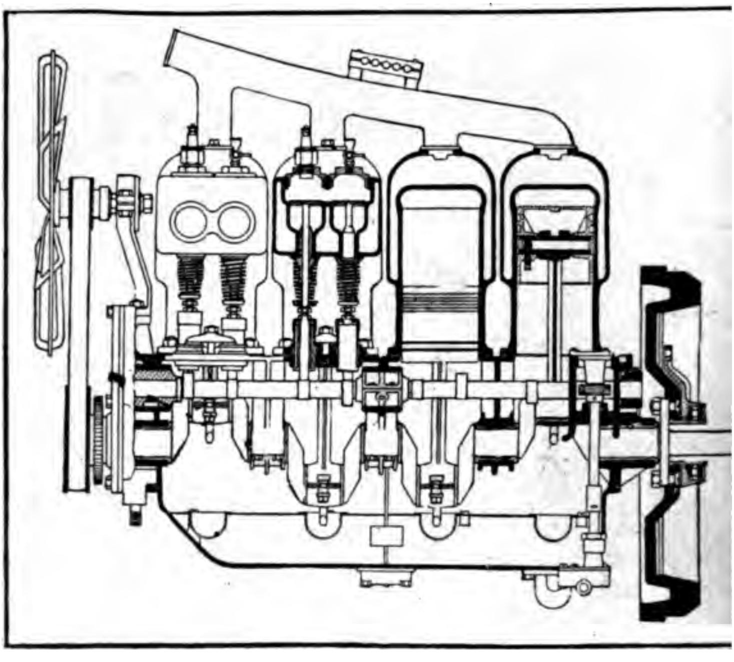
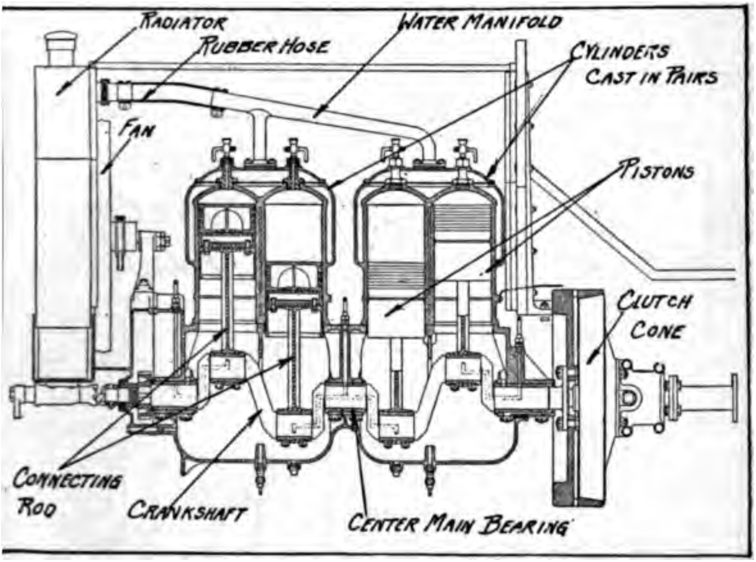


Fig. 97.—Longitudinal Sectional View of Overland Four Cylinder M a Type Having Individual Cylinder Castings and a Five Bea Crankshaft.

are more easily handled, but where these are used it is absol necessary to mark them so that they will always be replac proper position. In most cases, the cylinders are duplicat each other and if they were not marked it would not be dif to transpose them on the engine base, an undesirable procee

In order to familiarize the motorist or novice repairman *engine construction* a side sectional view of a typical power

the position it occupies in the car frame is shown at Fig. 98, ile a front sectional view is shown at Fig. 99. This engine is a ar cylinder T-head form and is the same as that outlined in illusations at Fig. 90, which clearly indicate the external appearance the power plant. The various important parts are indicated ıd should be easily identified when working on engines of this pe. One of the most widely used of automobile power plants



ig. 98.—Longitudinal Sectional View of Locomobile Four Cylinder Motor Which Has Cylinders Cast in Pairs and a Three Bearing Crankshaft.

d one that practically all repairmen will have occasion to work at some time or other owing to the thousands in use in all rts of the world is that employed on the Ford Model T-automoe. This power plant is shown in part sectional view at Fig.). It is a unit power plant, as the planetary change speed gear; is carried in an extension of the engine crankcase. The four inders and upper portion of the crankcase are cast as a unit. e cylinder head is removable. One of the novelties of construc-

tion in this motor is the use of a flywheel magneto, the i
member carrying a series of U-shaped magnets which revol
a series of fixed field coils attached to a plate which d
rotate on account of being bolted to the engine crankcase
general construction of the engine may be readily asce
by careful inspection of the illustration.

Defects in Cylinders.—After the cylinders have been r
and stripped of all fittings, they should be thoroughly clean
then carefully examined for the defects enumerated at Fi

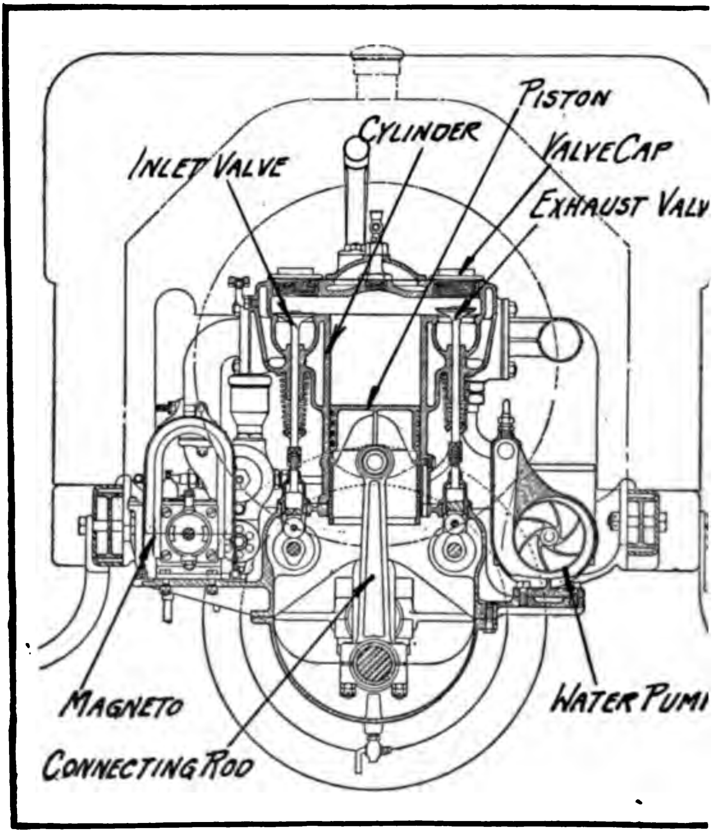
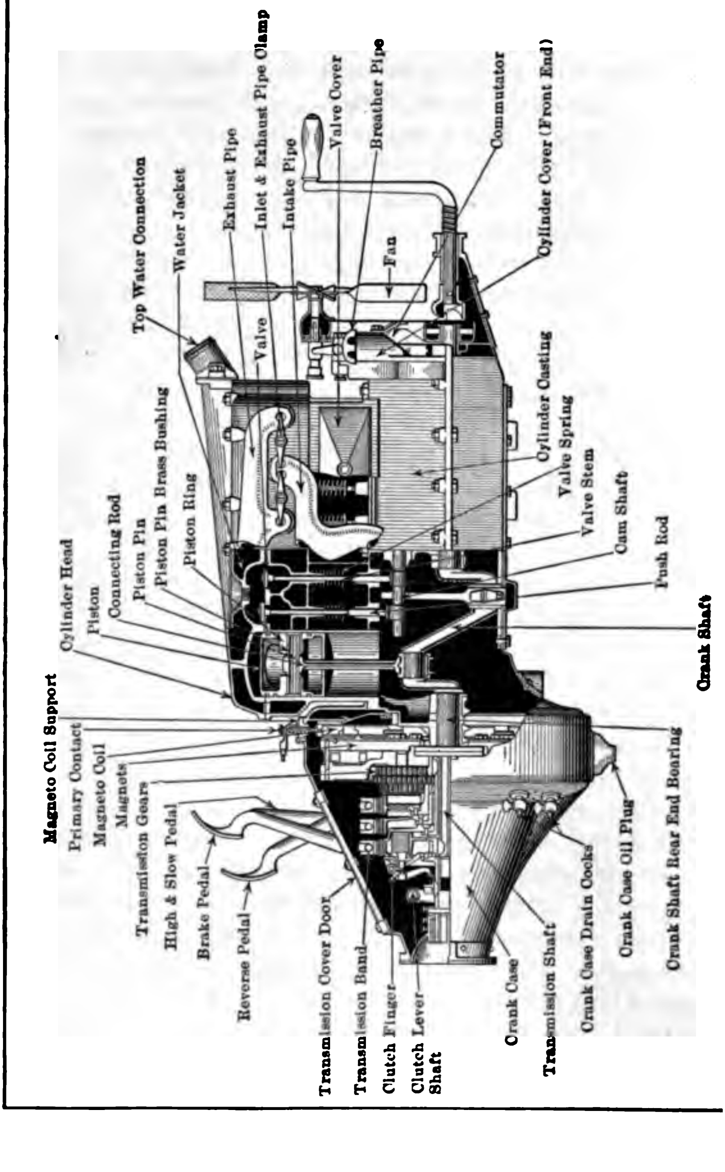


Fig. 99.—Front Sectional View of Locomobile Four Cylinder M

nterior or bore should be looked at with a view of finding marks, grooves, cuts or scratches in the interior, because there any faults that may be ascribed to depreciation at this point. ylinder bore may be worn out of round, which can only be nined by measuring with an internal caliper or dial indicator f the cylinder bore shows no sign of wear. The flange at the n of the cylinder by which it is held to the engine base may icked. The water jacket wall may have opened up due to ng of the jacket water at some time or other or it may be with scale and sediment due to the use of impure cooling . The valve seat may be scored or pitted, while the threads ig the valve chamber cap may be worn so that the cap will : a tight fit. The cylinder described is an individual casting : L-head form having integrally cast water jacket.

her forms of unit cylinders have been evolved, one of the widely used being that of the four cylinder Cadillac engines, is shown at Fig. 102. This incorporates several novelties istruction, one being the applied sheet copper water jacket, :her being the detachable cylinder head casting which is :d down against the top of the copper water jacket and held ce on the cylinder by an externally threaded close nipple. dvantages that were claimed for this construction are easy ement of one defective cylinder assembly part without scrap- e rest. For example, when the cylinder construction shown . 101 is used, if the cylinder bore is badly scored, the entire g must be thrown away, even though the water jacket, com- n and valve chambers are in perfect condition. With the ac construction, should the water jacket be faulty it is impos- o repair this easily owing to the material employed or to e it if repairs are not practical. If the cylinder should be , the water jacket and combustion head may be saved and a ylinder casting purchased at considerably less cost than that complete unit cylinder.

ny motors have been made by the Knox Company, using lually cast cylinders of the form shown in section at Fig. ., and completely assembled at B, in one view and with :r head *removed in the other.* This detachable head con-


Magneto Coil Support
Primary Contact
Magneto Coil
Magnets
Transmission Gears
High & Slow Pedal
Brake Pedal
Reverse Pedal
Transmission Cover Door
Transmission Band
Clutch Finger
Clutch Lever Shaft
Crank Case
Transmission Shaft
Crank Case Drain Cocks
Crank Case Oil Plug
Crank Shaft Rear End Bearing
Crank Shaft
Push Rod
Cam Shaft
Valve Stem
Valve Spring
Cylinder Casting
Cylinder Cover (Front End)
Commutator
Fan
Breather Pipe
Valve Cover
Intake Pipe
Inlet & Exhaust Pipe Clamp
Exhaust Pipe
Valve
Water Jacket
Top Water Connection
Piston Pin Brass Bushing
Piston Ring
Piston Pin
Connecting Rod
Piston
Cylinder Head

tion was necessary on account of having the valves seat directly ıst flat seatings machined in the head casting. The head cast- s provided with its own water jacket, as is the cylinder, con- ons being made between the two by a short bent pipe held .ace by the same stirrup member that holds the manifold to :ylinder. The detachable head construction makes it possible move that member and obtain ready access to the piston tops craping out carbon without taking the main cylinder portion . the crankcase. When the valves need grinding the head may emoved and carried to the bench where the work may be per- ıed with absolute assurance that none of the valve grinding ɔound will penetrate into the interior of the cylinder as is ·times unavoidable with the L-head cylinder shown at Fig. or the T-head form outlined at Fig. 99, in which the valve ngs are in pockets cast integrally with the cylinder.

'he detachable head construction has only recently become ılar, though it was one of the earliest forms of automobile en- construction. In the early days it was difficult to procure ets or packings that would be both gas and water tight. The t asbestos commonly used was too soft and blew out readily. des a new gasket had to be made every time the cylinder head removed. Woven wire and asbestos packings impregnated rubber, red lead, graphite and other filling materials were : satisfactory than the soft sheet asbestos but were prone to ı out if the water supply became low. Materials such as sheet ·er or brass proved to be too hard to form a sufficiently yield- packing medium that would allow for the inevitable slight :uracies in machining the cylinder head and cylinder. The ntion of the copper-asbestos gasket, which is composed of two ts of very thin, soft copper bound together by a thin edging he same material and having a piece of sheet asbestos inter- d solved this problem. One of the first engines to use the de- able cylinder head piece was the Ford, and at the time it was introduced it was met with considerable criticism on the part utomobile engineers. That this proved unfounded and based ɔersonal prejudice is clearly demonstrated at this time by the : use of the detachable head construction. Copper-asbestos

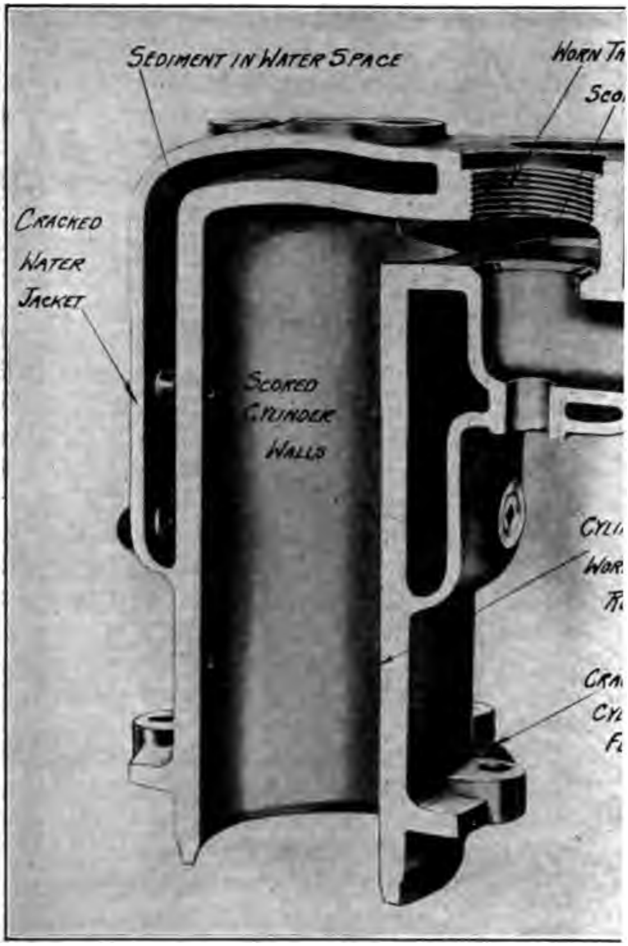


Fig. 101.—Sectional View of Automobile Engine Cyli Defects that Will Reduce Engine Efficiency.

packings form an effective seal against leakage of positive retention means for keeping the explosion p cylinder.

The great advantage of the detachable head is tha *very easy inspection* of the piston tops and combu

interiors which can only be done with cylinders of the L, or T, for by removing the cylinder from the engine base. Two forms removable cylinder heads are shown at Fig. 104. They are simil in design and utilize the same form of gasket, the only differen being that the type shown at A, serves two cylinders while the one outlined at B, covers the four cylinders. The construction at A, is used on the Oakland car while that at B, is found on the Ford, Metz, Regal, Cartercar, Maxwell, Oakland and several others. The cylinder heads are securely held by substantial retention bolts and if these are properly tightened and the gasket is in good condition there is not likely to be any loss in pressure due to leakage. One of the most important things to look for when the cyli der has been removed or the cylinder head taken off, if that meth of construction is followed, is carbon deposits. These accumula at the various points indicated at Fig. 105, namely the piston to valves, around the spark plug and at several points in the co bustion chamber.

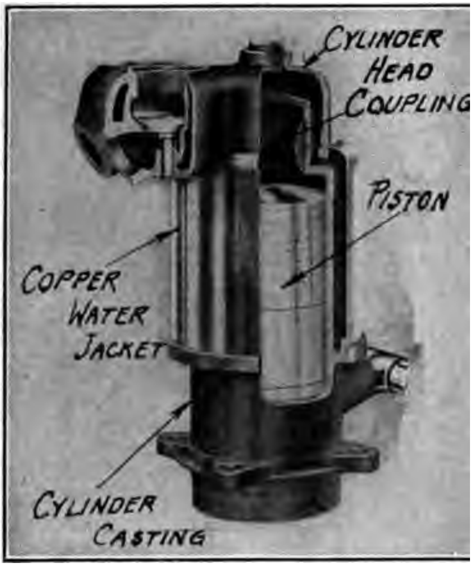
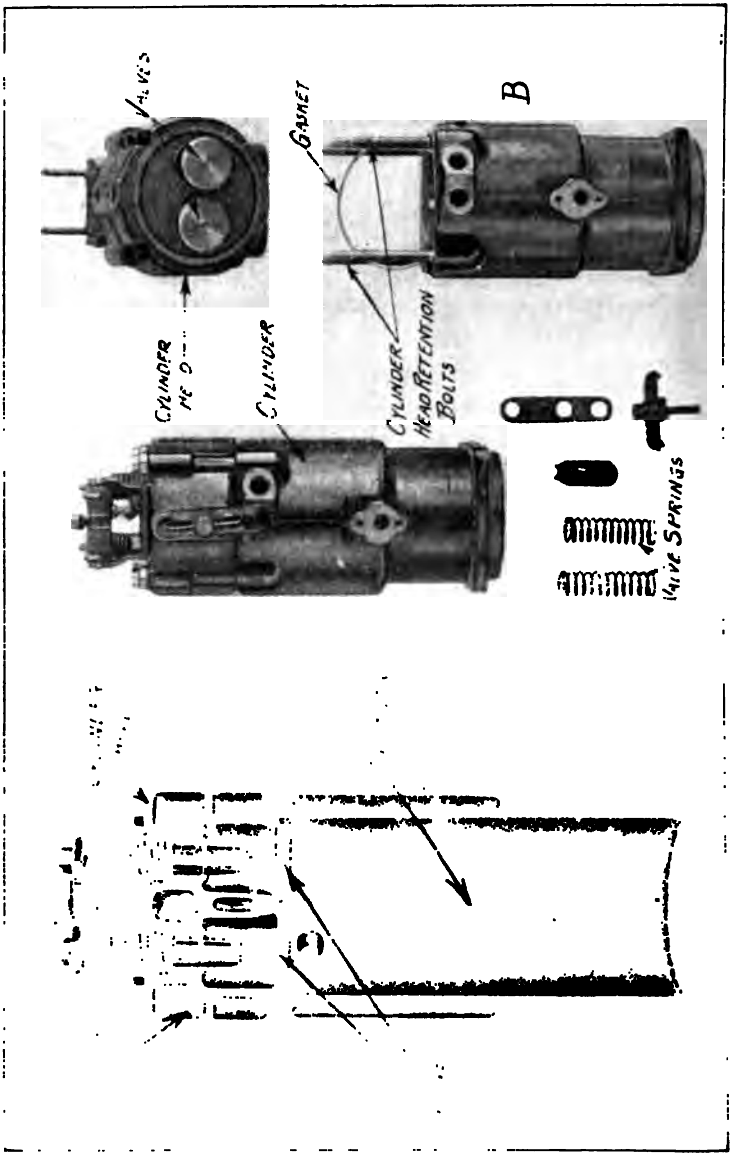


Fig. 102.—Cylinder of Cadillac Four Cylin Motor Using Applied Copper Water Jacke

Carbon Deposits, Their Cause and Prevention.—Most autho ties agree that carbon is the result of imperfect combustion of t fuel and air mixture as well as the use of lubricating oils of i proper flash point. Lubricating oils that work by the piston rin may become decomposed by the great heat in the combusti chamber *but at the same time one* cannot blame the lubricat



VALVES
GASKET
B
CYLINDER
CYLINDER HEAD RETENTION BOLTS
VALVE SPRINGS

il for all of the carbon deposits. There is little reason to suspect hat pure petroleum oil of proper body will deposit excessive mounts of carbon, though if the oil contains a resinous or animal at filler there would be much carbon left in the interior of the ombustion chamber. Fuel mixtures that are too rich in gasoline lso produce these undesirable accumulations.

A very interesting chemical analysis of a sample of carbon craped from the interior of a motor vehicle engine shows that rdinarily the lubricant is not as much to blame as is commonly upposed. The analysis was as follows:

Oil	14.3%
Other combustible matter	17.9
Sand, clay, etc.	24.8
Iron oxide	24.5
Carbonate of lime	8.9
Other constituents	9.6

It is extremely probable that the above could be divided into wo general classes, these being approximately 32.2% oil and comustible matter and a much larger proportion or 67.8% of earthy natter. The presence of such a large percentage of earthy matter s undoubtedly due to the impurities in the air, such as road dust which has been sucked in through the carburetor. The fact that ver 17% of the matter which is combustible was not of an oily ature lends strong support to this view, while the ratios of the onstituents of the incombustible material to one another is very early what would be expected in débris from ordinary macadam oads. If one assumes that half of the combustible matter, not of ily derivation, comes from the road dust and that one-fifth of the xide of iron also arises from this source, the approximate composiion of this cylinder deposit may be expressed as follows:

Residual matter from oil	23%
Iron dust due to friction in cylinder	20
Road dust	57

It will be evident that fully 50% of this deposit can be attributed to the ordinary dust of the highway and not to excessive fuel or an impure *grade of lubricating oil.* While it is imperative to

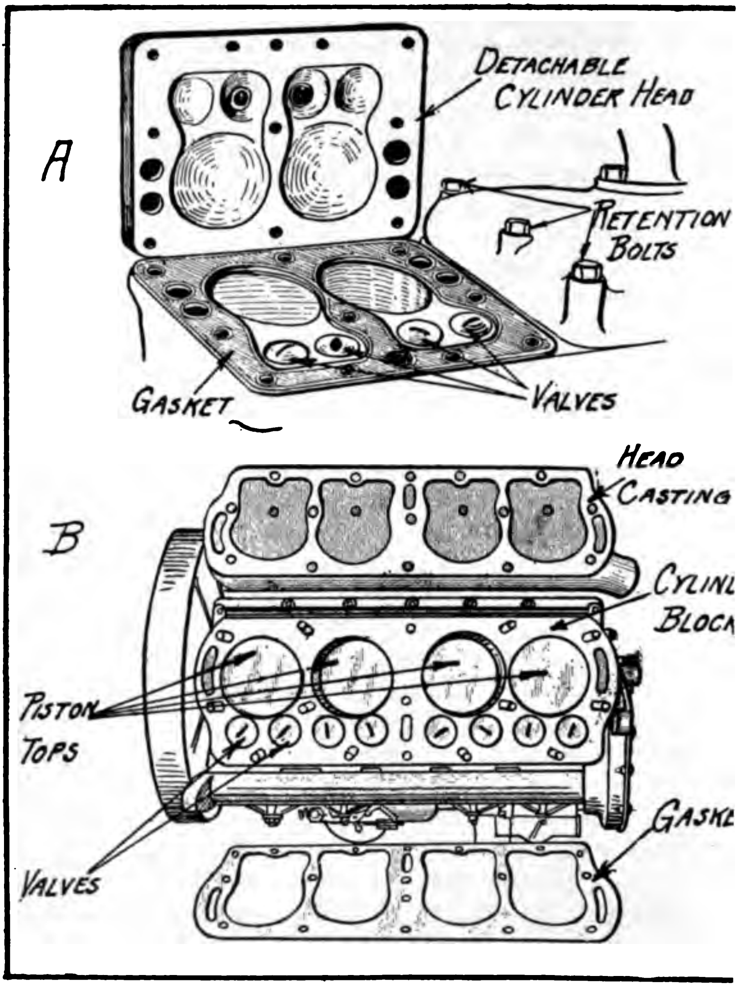


Fig. 104.—Showing Utility of Detachable Cylinder Heads and How T Make for Superior Accessibility of Valves and Combustion Chamb

use as little gasoline in the mixture as possible and to supply the proper quantities of high grade lubricating oil, it wil evident that even if these precautions were carefully obse

would still be considerable deposit as the result of the im-
:s drawn in through the carburetor. It is very good practice
ride a screen on the air intake to reduce the amounts of dust
. in with the air as well as observing the proper precautions
e to supplying the proper quantities of air to the mixture
not using any more oil than is needed to insure proper lubri-
of the internal mechanism.

e of Carbon Scrapers.—It is not unusual for one to hear an
obile driver complain that the car he drives is not as respon-
s it was when
fter he has run
it very few
s. There does
em to be any-
actually wrong
the car, yet it
ot respond read-
the throttle and
t to overheat.
these symptoms
a rundown con-
of the mechan-
the trouble is
due to nothing
serious than ac-
ations of carbon.
medy is the re-
of this matter
place. While

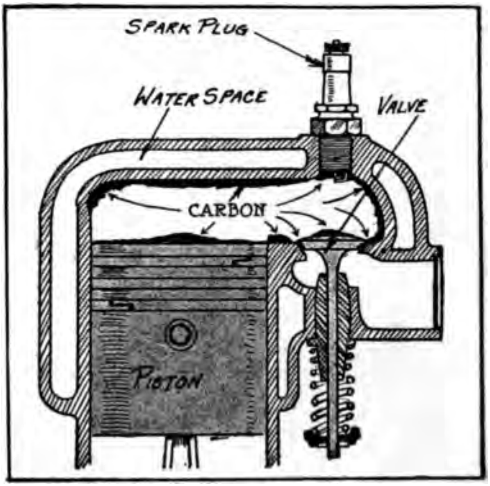


Fig. 105.—Sectional View of Upper Portion of Cylinder Showing Point Where Carbon Deposits Accumulate.

rest way of cleaning the inside of the motor thoroughly
emove the cylinders, if these members are cast integrally
the head or of removing the head member if that is a
te casting, to expose all parts, there are other methods that
een recommended that may be depended on to reduce the
t of carbon deposits. A number of carbon solvents of a
composition have been offered which may be introduced into
linder *through the spark plug* openings or valve cap holes

that are said to soften the accumulation, and permit it to be out through the exhaust when the engine is again starte(the material is used. The writer believes that there is n less "fake" about these compositions as chemical analysis o has disclosed the composition, which on careful study of cau

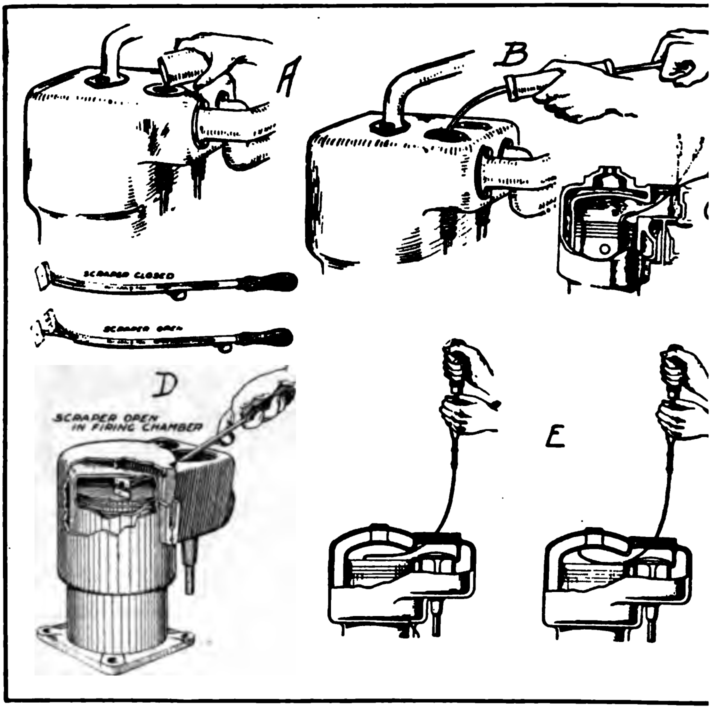


Fig. 106.—Outlining Use of Scrapers in Removing Carbon Deposit Combustion Chamber Interior.

effect, does not seem to justify all the claims made for them enthusiastic advertising men responsible for their promotion widely advertised carbon remover of liquid form was founc composed largely of acetone. Another was practically deo(kerosene and denatured alcohol mixture. Another of grai *form* was discovered to be practically common salt. Ther(

question in the writer's mind but that a solvent like acetone wou soften carbon deposit enough so it could be readily removed l scraping. The method of using the solvent is to bring the pist in the cylinder to be cleaned up to the end of its compressi stroke at which time both valves are closed and to pour in a defini quantity of the solvent through a valve cap or spark plug openin This operation is outlined at Fig. 106, A. After the liquid has be allowed to soak thoroughly into the carbon deposits for perio varying from two to six hours it is drawn out of the cylinder l means of a syringe as shown at Fig. 106, B. When the engine started after all cylinders have been treated in turn the exhau will be very smoky and filled with carbon particles, this indicati that considerable quantities of the carbon has been dissolved. Th treatment is not always successful, as it would be more apt to r move the soluble carbon, as is due from burnt lubricating oil, rich mixture than it would be to act upon the earthy material th the chemical analysis shows, exists in the deposits.

In certain forms of cylinders, especially those of the L, or form, it is possible to introduce simple scrapers down through tl valve chamber cap holes and through the spark plug hole if th component is placed in the cylinder in some position that co municates directly to the interior of the cylinder or to the pist top. This method is particularly applicable to engines havi valves on opposite sides, namely those employing cylinders of tl T form. No claim can be made for originality or novelty of th process as it has been used for many years on large stationary e gines. The first step is to dismantle the inlet and exhaust pipi and remove the valve caps and valves, although if the deposit is n extremely hard or present in large quantities one can often m nipulate the scrapers in the valve cap openings without removi either the piping or the valves. Commencing with the first cylinde the starting crank is turned till the piston is at the top of its strok then the scraper may be inserted, as indicated at Fig. 106, C, an the operation of removing the carbon started by drawing the to toward the opening. As this is similar to a small hoe, the cutti edge will loosen some of the carbon and will draw it toward t opening. A swab is made of a piece of cloth or waste fastened

the end of a wire and well soaked in kerosene to clean cylinder. When the engine is of a T-head type and the val removed it is possible to introduce a ball of waste at one p: push it clear through the cylinder and out of the other valv this bringing much loosened carbon out with it.

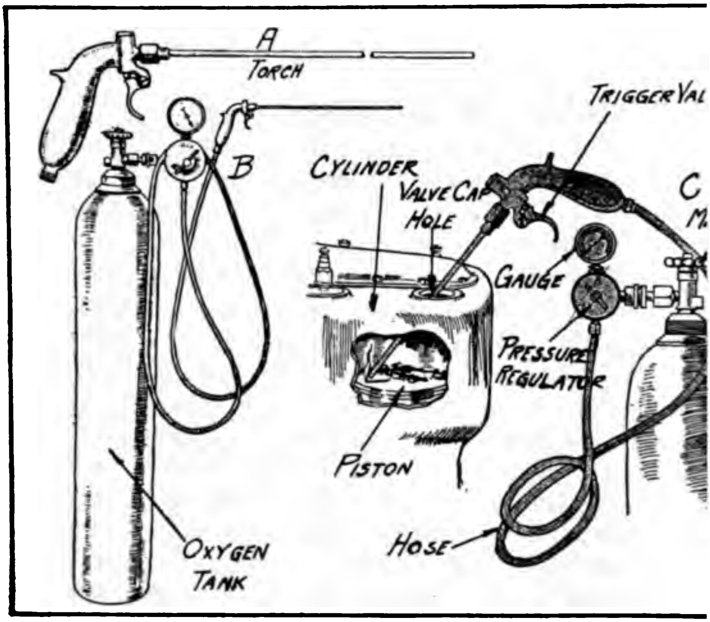


Fig. 107.—How Oxygen May be Used to Remove Carbon by a C tion Process.

When available, an electric motor with a length of flexibl and a small circular cleaning brush having wire bristles used in the interior of the engine. The electric motor need over one-eighth horsepower running at 1,200 to 1,600 R. P.] the wire brush must, of course, be of such size that it can b inserted through the valve chamber cap. The flexible shaft] one to reach nearly all parts of the cylinder interior withou culty and the spreading out and flattening of the brush insu *considerable surface* will be covered by that member.

hile the carbon scrapers may be easily made by any mechanic, ted forms are available at small cost which have advantages y of consideration. The tool shown at Fig. 106, D, is known il's carbon scraper and was designed for use in any T, or ead motor by re- ng the valve caps urning the motor until the piston s to the top cen- The scraper is inserted in a d condition gh either valve and after it is e the combustion ber the expand- ar may be pulled and the scraper s will spread gh to conform to ize of the firing ber. Moving the per vigorously and forth and d the side wall a few minutes s the carbon de- When this has

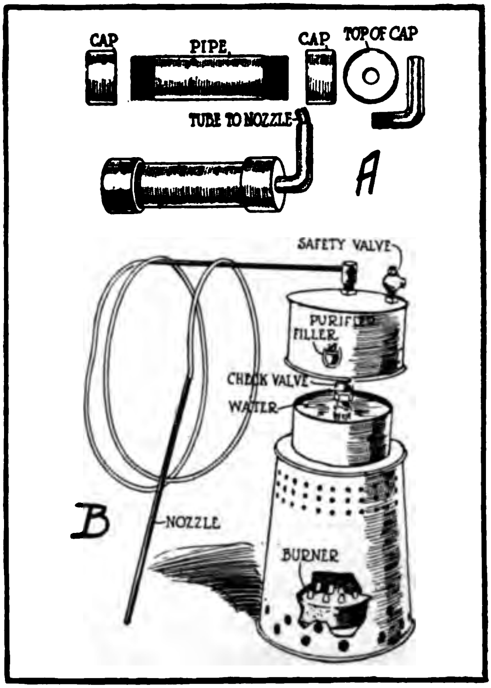


Fig. 108.—Simple Oxygen Generator.

done all carbon should be scraped into the valve chamber the closed scraper end and either spooned out with that mem- r blown out with compressed air. A soft cloth saturated with ene is then placed between the blades of the scraper, turning member into a mop and if reinserted into the cylinder will ve any of the fine particles of carbon which might be left in. The device is made of high grade spring steel with hard- cutting blades and has a considerable degree of flexibility. another form of flexible carbon scraper is shown at E, this

consisting of a flexible steel blade having a sharp hoe shaped end which is inserted through the valve cap opening and used in the manner indicated in the illustration.

Use of Denatured Alcohol in Removing Carbon.—In a paper read before the National Gas Engine Association, Joseph A. Anglada described the use of denatured alcohol as a solvent for removing the carbon deposits from the combustion chamber of explosive motors. The trials were made with single cylinder horizontal engines but there is no reason to doubt that equally as good results could be obtained in automobile power plants. The operation is described as follows:

Both of these engines were operated under a load applied by pressing a wooden lever against the fly wheel until the temperature of the jackets warmed to about one hundred and fifty degrees Fahrenheit. The engines were then stopped with the piston at the head end of the compression stroke. Both valves were closed. The compression space of each cylinder was then filled with Pyro denatured alcohol, which in the case of the International Harvester engine was left to soak for six hours and in the case of the Jacobson engine, about three and one-half hours. It was found that the exhaust valve of the International Harvester engine did not seat properly, because when the alcohol was first put in this engine it leaked past the exhaust valve. This leak, however, soon stopped probably due to the alcohol washing away whatever foreign matter was lodged between the valve and its seat.

At the end of these periods, both engines were cranked by hand for a few revolutions and then started in the usual way, on gasoline. The exhaust in both instances, when the engine was started, contained a large quantity of black smoke and upon opening the compressed relief cock of each engine a bombardment of small incandescent particles of carbon was seen and felt on each firing stroke, showing that the alcohol had loosened the carbon deposits in these engines. In each case some of the alcohol leaked past the piston into the crank case, showing that the piston rings were not liquid tight. In this connection it is advisable to note that almost invariably lubricating oil will collect in the piston ring grooves where it becomes partially solidified in the form of a

ummy material of sufficient strength to prevent the proper operaion of the piston rings. The result is that the lubricating oil which is fed to the cylinder is called upon in a very large measure o assist the piston rings in making a gas-tight joint with the ylinder wall. When denatured alcohol is introduced into the ylinder in sufficient quantity, it will dissolve the gummy deposit and permit the piston rings to slide freely in their grooves and hus fit themselves more perfectly to the cylinder walls. That his occurs has been proven by tests on a number of automobile notors which after treatment with denatured alcohol have shown n increase in power as well as in flexibility.

From a very complete series of experiments conducted with utomobile motors which had been in service for different lengthy eriods of time, in addition to experiments conducted with a few narine and stationary motors, I have arrived at the following onclusions:

(1) Denatured alcohol is an efficient decarbonizer for all types f gasoline engines.

(2) It does not injuriously affect the surfaces of the metals ith which it comes in contact.

(3) Heat is not necessary when using denatured alcohol as a ecarbonizer.

(4) Heat accelerates the action of denatured alcohol when used s a decarbonizer.

(5) Denatured alcohol when introduced in the combustion pace of an automobile cylinder which is at the working temperaure of the engines will loosen the carbon deposits so as to permit he deposit to become separated from the walls of the combustion pace and pass out of the cylinder with the exhaust gases when he engine is run.

(6) The best results from the use of denatured alcohol, a arbon remover, are obtained when the combustion space of a hot ngine is entirely filled with liquid denatured alcohol and pernitted to soak for a period of not less than six hours.

(7) Denatured alcohol will act as a carbon remover when the ngine is cold, provided the liquid denatured alcohol is in contact with the *carbon covered surfaces.* The action of denatured alcohol

under these conditions is about half as rapid as when the engine is hot.

(8) The action of denatured alcohol as a carbon remover when introduced in small quantities into the combustion space of a cold automobile engine is positive, but slow.

(9) Where the fit between the piston rings and cylinder walls is imperfect, denatured alcohol will leak past the pistons into the crank case and cause the oil in the crank case to become unfit for use for lubricating the engine. However, when a sufficient amount of denatured alcohol has been added to this oil and circulated through the lubricating system of the motor for a very short time, in order to obviate the possibility of damaging the wearing surfaces of the engine, denatured alcohol acts as a cleansing agent, as evidenced by the unusual amount of foreign matter withdrawn with the denatured alcohol treated oil and the subsequent improved action of the engine.

(10) Due to the cleansing action of denatured alcohol as noted in the preceding conclusions, an engine which has been in service for an extensive period will show a marked increase in operating efficiency when thoroughly treated with denatured alcohol.

(11) It is advisable to introduce, in the matter noted in the experiments, from two to four ounces of denatured alcohol (depending upon the size of the cylinders) into each cylinder of an engine, at intervals of about three days, in order to keep the cylinders freed from carbon deposits.

Burning Out Carbon with Oxygen.—A process of recent development that gives very good results in removing carbon without disassembling the motor depends on the process of burning out that material by supplying oxygen to support the combustion and to make it energetic. A number of concerns are already offering apparatus to accomplish this work, and in fact any garage using an autogenous welding outfit may use the oxygen tank and reducing valve in connection with a simple special torch for burning the carbon. Results have demonstrated that there is little danger of damaging the motor parts, and that the cost of oxygen and labor is much lower than the old method of removing the cylinders and scraping the carbon out, as well as

ng very much quicker than the alternative process of using bon solvent. The only drawback to this system is that there o absolute insurance that every particle of carbon will be oved, as small protruding particles may be left at points that flame does not reach and cause pre-ignition and consequent ding, even after the oxygen treatment. It is generally known carbon will burn in the presence of oxygen, which supports ustion of all materials, and this process takes advantage of fact and causes the gas to be injected into the combustion ber over a flame obtained by a match or wax taper.

is suggested by those favoring this process that the night e the oxygen is to be used that the engine be given a con- onal kerosene treatment. A half tumbler full of this liquid denatured alcohol is to be poured into each cylinder and itted to remain there over night. As a precaution against the gasoline is shut off from the carburetor before the torch erted in the cylinder and the motor started so the gasoline e pipe and carburetor float chamber will be consumed. Work ne on one cylinder at a time. A note of caution was recently led by a prominent spark plug manufacturer recommending the igniter member be removed from the cylinder in order o injure it by the heat developed. The outfits on the market st of a special torch having a trigger controlled valve and a h of flexible tubing such as shown at Fig. 107, A, and a lating valve and oxygen tank as shown at B. The gauge d be made to register about twelve pounds pressure.

he method of operation is very simple and is outlined at C. burner tube is placed in the cylinder and the trigger valve is ed and the oxygen permitted to circulate in the combustion ber. A lighted match or wax taper is dropped in the cham- and the injector tube is moved around as much as possible to cover a large area. The carbon takes fire and burns briskly e presence of the oxygen. The combustion of the carbon is npanied by sparks and sometimes by flame if the deposit is oily nature. Once the carbon begins to burn the combustion nues without interruption as long as the oxygen flows into ylinder. Full instructions accompany each outfit and the

amount of pressure for which the regulator should be set depend upon the design of the torch and the amount of oxygen containe in the storage tank.

How Oxygen Is Produced.—While the best results are ob tained by the use of the proper burner and compressed oxyge tank, it is possible to generate oxygen by very simple mechanism and for the ingenious repairman to extemporize a burner that wil give fairly good results in removing the carbon. The simples method of producing oxygen is by heating a mixture of potassiun chlorate and manganese dioxide. Although oxygen may be pro duced by heating potassium chlorate alone, the combination o the manganese dioxide acts as a stimulating agent which not onl gives out oxygen, but which assists in breaking up the chlorate s that more of the gas will be evolved. At Fig. 108, A, an ex tremely simple oxygen generator that can be made by any repair man is outlined. The basis of the device consists of a 5 or 6-inc length of seamless iron pipe, one and one-half or two inches i diameter. The pipe is threaded at each end and standard pip caps are fitted, one of these being drilled and tapped to receiv a one-eighth inch brass pipe. This is bent in the form of an e and a piece of flexible copper tubing is soldered into the end o the pipe. In order to operate this generator the unperforate cap is unscrewed and a mixture composed of two ounces of pota sium chlorate and one tablespoonful of manganese dioxide is place in the pipe. The cap is screwed back in position and the flam of a blow torch is used to heat the bottom of the iron pipe. In short period oxygen gas will issue from the end of the copper tub joined to the generator by rubber hose, which should be place inside of the combustion chamber against the carbonized are A lighted match or taper thrown into the cylinder will start con bustion of the carbon.

One of the latest forms of oxygen generator is shown at Fi 108, B. The feature is that the oxygen is evolved by heating special cartridge by an alcohol burner. The oxygen gas pass through a purifier which is provided with a safety valve to preve accumulation of excess pressure. The purifier is connected wit the oxygen generating chamber by a one-way check valve whic

permits the gas to flow into the purifier, but not from that memb(into the generating chamber. The cartridges or charges weig six pounds and sell for one dollar apiece. A cupful of water placed on top of the cartridge to prevent the solder on that men ber from melting. When the flame plays on the bottom of tl cartridge, which also acts as a generating chamber, the oxyge issues from the hole in the center into the purifying chamber.

Repairing Scored Cylinders.—If the engine has been run any time without adequate lubrication, one or more of the cyli ders may be found to have vertical scratches running up and dow the cylinder walls. The depth of these will vary according to tl amount of time the cylinder was without lubrication, and if tl grooves are very deep the only remedy is to purchase a ne member. Of course, if sufficient stock is available in the cylind walls, the cylinders may be rebored and new pistons which a oversize, i.e., larger than standard, may be fitted. Where tl scratches are not deep they may be ground out with a high spee emery wheel or lapped out if that type of machine is not availabl Wrist pins have been known to come loose, especially when the are retained by set screws that are not properly locked, and wrist pins are usually of hardened steel it will be evident th the sharp edge of that member can act as a cutting tool and mal a pronounced groove in the cylinder. Cylinders that have bee damaged in this manner have sometimes been repaired by tl autogenous welding process, the oxy-acetylene flame being us to fuse new cast iron into the groove, then grinding out the rid of excess material in order to obtain a smooth bore. Cylind grinding is a job that requires skilled mechanics, but may l accomplished on any lathe fitted with an internal grinding attac ment.

When a car that has been used for a considerable length time is overhauled it may be found that the cylinder bore w have worn enough so reboring will be necessary. The wear commonly found about midway the length of the cylinder wal as it is at this point that the connecting rod side thrust is greate due to the angularity of that member. In order to remedy tl defective condition *some repairmen* are content with merely

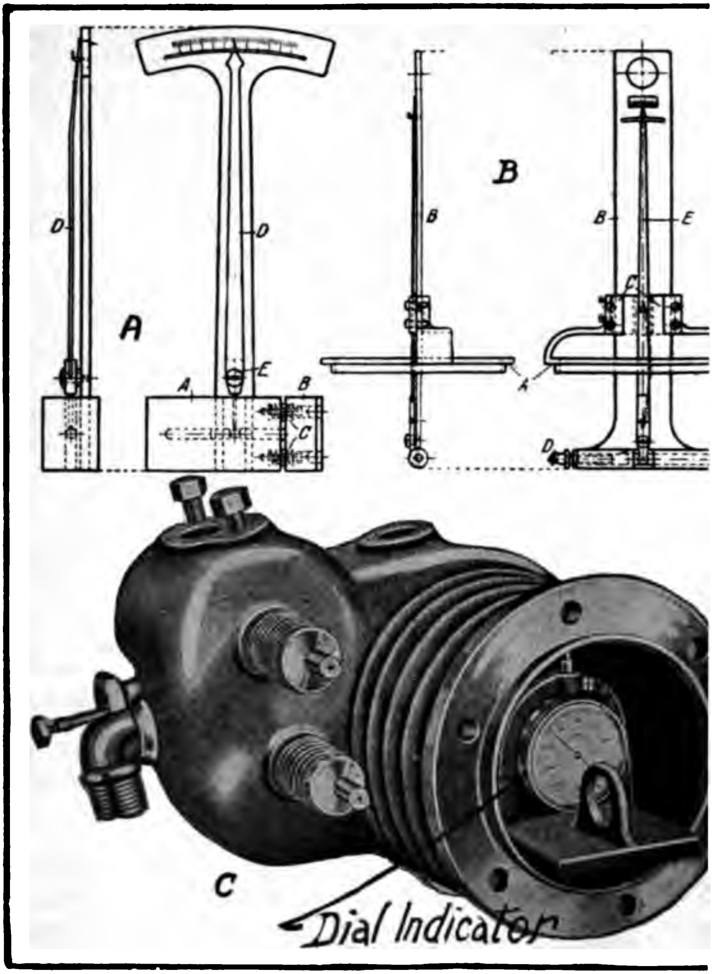


Fig. 109.—Appliances for Measuring Cylinder Bore to Determine A of Wear.

ting new piston rings of slightly larger circumference, b plan is not wholly satisfactory, because if the rings are c ciently small diameter to enter the unworn portion of th when they spring out into the worn part there must e *wide a gap at the* slots. For this reason most mechanics

either a new cylinder and piston or to rebore the cylinder fit a larger piston with correspondingly larger rings.

f the car is an old one and it is not considered wise to spend noney necessary to restore the cylinder bore to correct shape, can get considerably more service by a simple expedient of ing new piston rings with long stepped ends. In this case will pass the smaller portions of the bore and expand suffi- ly to fill the worn parts. As there is no gap between the ends, when fully expanded, there will be but little loss of com- sion, such as might be possible with either butt joint or diag- cut rings under the same conditions. One precaution is itial, however, and that is to insure that the grooves are of cient width to take step cut rings having substantial steps. ie piston rings are narrow, the ends are apt to snap off at the s. If the grooves are turned out to a greater width, new piston s must be made to fit. The compression is much improved and er is increased as the rings with the long stepped joint will w the worn bore, constricting as the bore is smaller and filling as the wear increases.

t is not difficult to measure the bore to find out if the walls are 1. Different calipers have been devised for this purpose, some hich are illustrated at Fig. 109. These are usually constructed he multiplying gauge principle so that the slightest inaccuracy be magnified at the dial. In the device shown at A, a fixed k, A, carries a standard on which is fulcrumed the indicating lle, D. This indicating needle is in contact below the fulcrum a plunger pin attached to the movable block D, which is ally kept pressed out by the coil spring C. If any irregu- ies are present the block B indicates them by its movement, h is translated to the short arm of the indicating lever D, h is fulcrumed at E. Another form of indicator working on tically the same principle except that the indicating lever E tuated by the plungers DD, is shown at B. The use of the s Dial Indicator, carried by a special fixture for use in de- ining the truth of bore of automobile cylinders, is so clearly n at Fig. 109 that it will not be necessary to mention the iple of operation any further than to state that the internal

mechanism of the indicator is such that the needle will indicat variations of less than .001 inch.

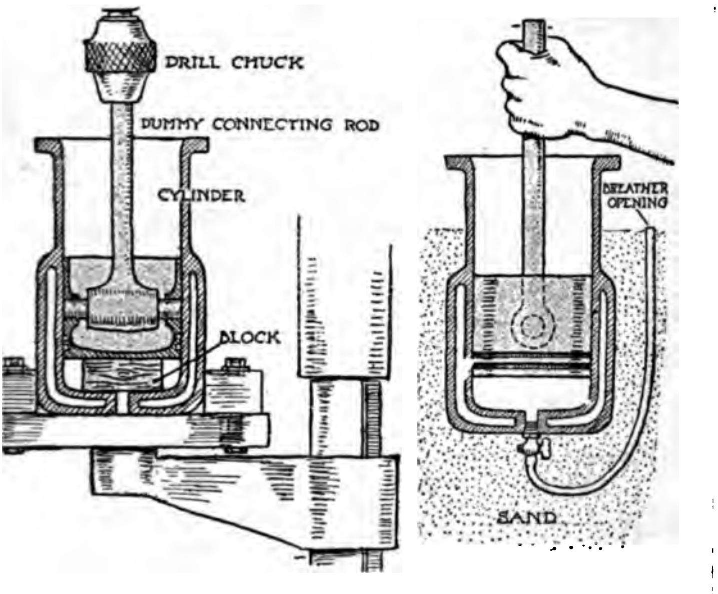
Where the grooves in the cylinder are not deep or where it ha warped enough so the rings do not bear equally at all parts o the cylinder bore, it is possible to obtain a fairly accurate degre of finish by a lapping process in which an old piston is coate with a mixture of fine emery and oil and is reciprocated up an down in the cylinder as well as turned at the same time. Thi may be easily done by using a dummy connecting rod having onl a wrist pin end boss, and of such size at the other end so tha it can be held in the chuck of a drill press. The cylinder castin is firmly clamped on the drill press table by suitable clampin blocks, and a wooden block is placed in the combustion chambe to provide a stop for the piston at its lower extreme positio The back gears are put in and the drill chuck is revolved slowl All the while that the piston is turning the drill chuck shoul be raised up and down by the hand feed lever, as the best result are obtained when the lapping member is given a combination o rotary and reciprocating motion.

Even if power is not available, the repairman need not be di couraged, because very good results may be obtained by han lapping. The same method is used as for lapping by power. Th abrasive material is composed of very fine emery and light ma chine oil, and is renewed from time to time and the cylinder cleane out to remove the old lapping compound before any new mixtur is introduced. A cylinder may be easily supported in a box o sand, as indicated, the compression relief petcock in the top o the cylinder being provided with a piece of rubber hose whic projects above the surface of the same, and which acts as a breathe opening for escape of the air compressed by the downward strok of the lap.

Where the cylinders are cast in block, as is now common pra tice on nearly all automobiles of recent development, it is no difficult to hold the cylinder block, as this is of sufficient size an weight to stand upright on the bench without clamping it dow While the writer has used this method in repair work over te years ago, he wishes to acknowledge his indebtedness to Motor Ag

ıe clear illustrations used. The process of lapping is coı l until the entire interior of the cylinder is bright and clea he scratches practically removed. All abrasive material vashed out of the cylinder with gasoline and the walls wipe vith a soft cloth.

ɔw to Repair Cracked Water Jacket.—The water jacket ‹ engine cylinder will sometimes become cracked due to free



110.—Outlining Use of Dummy Piston and Connecting Rod foı Lapping Out Fine Scratches in Cylinder Bore.

: the cooling water, or perhaps as a result of a sand or blo vhich opens up from vibration after the cylinder has bee ıwhile. At the present time the usual practice in repairir ers is to fill the depression or crack with iron by the autog velding process, although various iron cements may be usı ıat purpose if the fracture is not serious. A mechanic is *always possible, i.e., a metal* patch can be applied

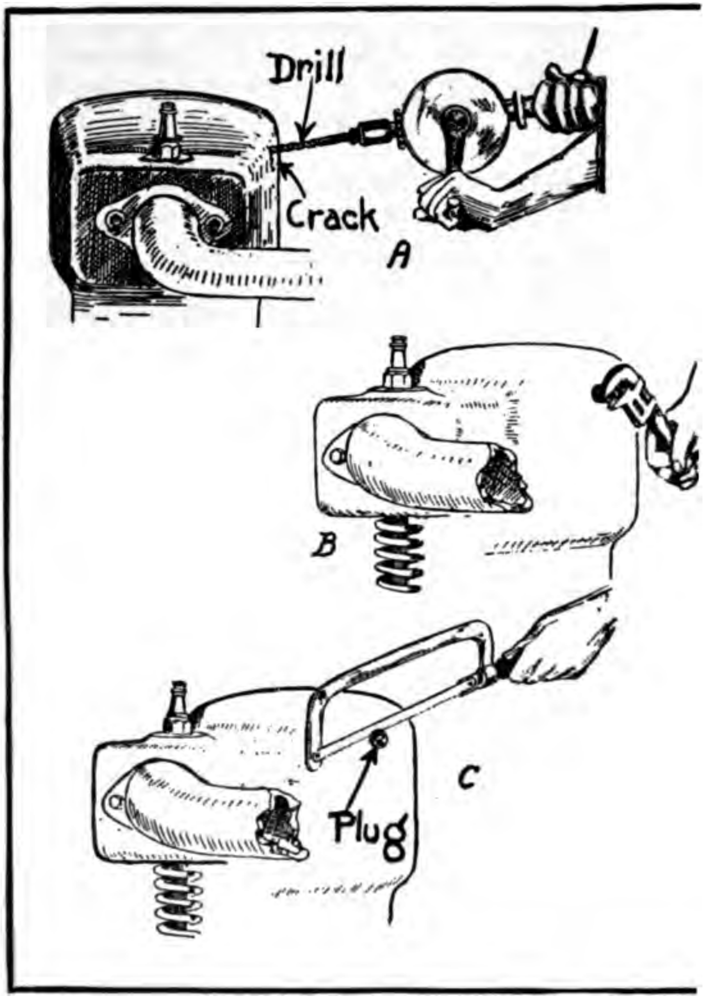


Fig. 111.—Method of Using Pipe Plug for Sealing Fine Cracks (Holes in Cylinder Water Jacket.

cover the crack and held in place against a gasket interp tween the plate and the cylinder jacket by small machin tapped into the iron. Where only a small blow hole exi *small crack the* mechanical method shown at Fig. 111 is

his consists of drilling a hole of sufficient size to take a standard ipe plug either $\frac{1}{8}$ inch or $\frac{1}{4}$ inch, according to the size of the ole as shown at A. A pipe plug is screwed into the tapped hole s shown at D, and when it has been forced in place after coatng the threads with red lead and oil or pipe joint compound to nsure a tight joint, the projecting portion of the plug may be ut off with a hacksaw as outlined at Fig. 111, C, and the remaing portion of the plug filed flush with the outside of the water acket.

If the crack is of some length it may be repaired by the folowing method. On the line of the fracture, drill and tap for a $\frac{1}{8}$-inch threaded copper rod. This rod is screwed in firmly to a epth about equal to the thickness of the metal of the water jacket. ut off the copper rod with a hacksaw, allowing it to project about $\frac{1}{32}$ inch; then drill succeeding holes, each hole being drilled partly nto the previously inserted copper plug, so that when all of the lugs are placed in the cylinder casting, they form a continuous and of copper along the line of the fracture. The copper plugs hould now be peened down and trimmed off flush. The only ossible chance for leakage, after having repaired the crack in his manner, is for the water to follow the joint between the metal f the jacket and the copper plugs, but as the copper rods are hreaded into the casting, it is not likely to occur. Should leakage ake place, a little extra peening will suffice to prevent it.

Still another method involves fusing copper filings or granuated brass spelter into the crack. This has the advantage of not equiring the removal of the part to be repaired. Drill and tap a mall hole at each end of the crack to prevent further extension f the weakness, and screw in an iron stud. Next clean the outide and inside of the fracture very thoroughly, using a scraper nd gasoline. File up some soft copper or brass spelter, and fill he crack, heaping the filings over it. Then take a powerful blow amp or a torch and direct the flame on the copper. By this ethod a fair amount of metal can be worked into the opening. fter cooling, the studs are cut off flush and the copper filed nooth. It is said that the repair will endure indefinitely.

In many cases the crack may be closed by making a rust joint.

The first step is to drill a very small hole at each end of the cra to prevent it from spreading and to drive in or screw in a me plug in each hole. The crack is then filled up with a paste ma of 66% fine iron filings or iron dust and 33% sal-ammoniac in t pulverized form, with just enough water to make a mixture proper consistency to be forced into the crack easily. The acti of the sal-ammoniac is to rapidly oxidize the fine iron filin producing rust which joins the various iron particles together a effectively seals the opening when it has properly hardened. a number of prepared cements for use with cast iron may purchased at low cost, it is often cheaper to buy the cement th to attempt to make it.

A correspondent to Machinery describes still another cem of somewhat different composition than that used with success the writer. This is composed as follows: powdered cast iron, parts; powdered sal-ammoniac, 1 part; powdered sulphur, ½ p These ingredients are thoroughly mixed together, and placed in air-tight receptacle in a perfectly dry condition until want When a hole in a casting is to be filled, take what appears to the required quantity of the mixed powder, moisten it with wa to the consistency of paste or putty, and fill the hole or depres smoothing it up and allowing it to set.

When very deep depressions are to be filled, add to the ab mixture an equal weight of fresh "vulcanite" Portland cement fore dampening. After the water has been added, so that mixture has the desired consistency, add non-volatile oil to extent of 8 per cent. by weight of the dry mixture used, and the mass until the oil is fully emulsified; then apply the p finishing with a facing of the original mixture containing no land cement. This will produce a filler which will not shri setting.

Another method sometimes employed is to clean out the in of the water jacket thoroughly and put in a solution of sul of copper or blue stone, allowing this to leak through the cr it will. Care is taken to remove any traces of grease that m main in the crack; this may be washed out by a boiling hot so *of potash or soda.* As the copper sulphate solution leaks

eposits a thin copper film, and if the crack is such that it permits nly a slow leak, the defective point will be sealed overnight with deposit of pure copper.

Inspecting Cylinder Head Packings.—On a number of over-ead valve type motors having the valves carried in a removable age gaskets are used to obtain a tight joint when the cage is crewed down. This packing frequently becomes soft, resulting n a leak around the valve. In multiple cylinder motors the gaskets hat are used at the point where the intake manifold joins the respective cylinders should be examined when the manifold is removed to make sure that these are in good condition. The gasket at the exhaust pipe should also be inspected. The packings for the inlet pipe may be of well shellacked cardboard, mobiline or other asbestos packing, or even sheet rubber, but those used on exhaust pipes should only be made of asbestos or copper-asbestos. A defective gasket on the inlet manifold will seriously attenuate the mixture going to all cylinders, while a defective packing under the exhaust manifold joints will have no effect upon the operation of the motor, the only result being a sharp hiss or whistling sound due to the leaky gas.

Engines of the detachable head form have packings that are made of a sheet of asbestos sandwiched between very thin sheets of copper. While these packings have the advantage of not depreciating rapidly, at the same time they may be packed down so solid and be so stiff that they will not allow the cylinder head to bed properly after they have been used for a time. As the packings for the popular cars using them may be purchased at low cost, it is well for the repairman to always have a supply of these on hand to fit the various cars he may undertake to repair. Some cylinders, especially of the individual casting form, have a hole at the top which is used for holding the core during the casting. This hole is usually filled with a plug tightly screwed into it, and the orifice should be tightly sealed against internal pressure or water leakage. These plugs are sometimes made of bronze, and it s not unusual to find that they will leak slightly as they have ecome loose due to the difference in ratios of the expansion be-ween the iron used for the cylinder and the metal of which the

plug is composed. If the cylinder is of this pattern, thi should be looked over carefully

It sometimes happens that the retaining flange at the l the cylinder may be cracked or a corner broken off. Wh preferred method of repair is to weld it in place with th acetylene torch, an emergency repair that will prove very sa

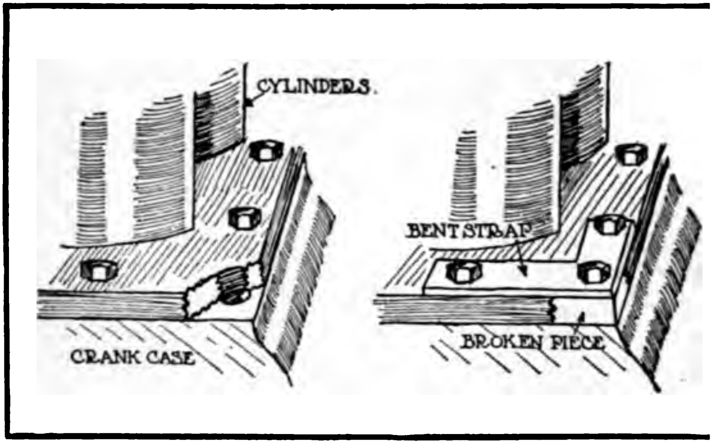


Fig. 112.—Repairing Broken Cylinder Base Flange.

tory may be made as indicated at Fig. 112. This involves t of a bent metal strap to hold the piece in place as ind While this broken piece does not assist in retaining the cy in place on the crankcase, it serves the useful purpose of k dirt and grit from entering the crankcase. The strap ass holding the cylinder, however.

A number of cylinder designs, especially those in whic or more cylinders are cast in a block, have a large plate side which is used to close the water jacket, this forming a for an opening which had been left to facilitate foundry when the cylinder was cast. This plate is either of sheet or aluminum; in some cases it may be an aluminum casting a portion of the intake manifold cast with it. Leakage *vented by* a packing interposed between the plate and the cy

te being firmly secured to the water jacket by a number of spaced machine screws. This is a common method of con-on and one often finds water leaks about the plate on in-n. The packing used is a rubber and fabric composition of m known by the trade name "Rainbow" steam packing. ay be easily cut to proper size and holes punched in with punch to allow the screws to pass through. In some in-simply removing the plate and smearing the gasket with or red lead and then replacing the plate, taking care to down all the screws tightly, will cure the leak. One ad-e of this plate is that it may be easily removed to permit pairman to clean out the water jacket thoroughly of any ulation of rust or sediment which may have become de-there and which will interfere with proper cooling. On orms of cylinders, applied copper water jackets are used, slight leak may be manifested at the lower joint. This may pped in most cases by just peening in the retention or ng ring, soldering or by calking with lead.

ve Removal and Inspection.—One of the most important of the gasoline engine and one that requires frequent in-n and refitting to keep in condition is the mushroom or valve that controls the inlet and exhaust gas flow. In uling it is essential that these valves be removed from their s and examined carefully for various defects which will be rated at proper time. The problem that concerns us now best method of removing the valve. These are held against ting in the cylinder by a coil spring which exerts its pres-n the cylinder casting at the upper end and against a suit-llar held by a key at the lower end of the valve stem. In to remove the valve it is necessary to first compress the by raising the collar and pulling the retaining key out of lve stem. Many forms of valve spring lifters have been ed to permit ready removal of the valves. The most com-rms that have received application in practice are shown at 113 and 114. The form shown at Fig. 113, A, is composed levers hinged together in such a way that squeezing the s together will spread the *other ends instead* of closing them

as is the case with pliers. One end of the tool is re: valve lift plunger, the other end bears against the val collar, as indicated. When the handles are pressed tog valve spring collar is raised, this compressing the spring mitting removal of the retaining key. A ratchet lock is to keep the handles closed so that both hands may b lifting the key out of the valve stem, if necessary. outlined at B consists of a hinge or supporting memb lever carrying a fork at one end to engage the valve spri The fulcrum member is carried by an adjustable sup which it is threaded. The supporting piece may be mo down on the fulcrum bolt, this adapting the tool for vari and sizes of valves. The device outlined at C consists o having a slotted bearing for the spring lifting bell crank s bolt, making it possible to move that member up or dowr the tool for different spaces between the valve spring colla valve operating push rod. The bell crank is lifted by which makes it possible to compress the heaviest val without trouble.

One objection against either of the forms of valve spr shown at A, B and C is that some means must be pr prevent the valve head from coming off its seat. This done by interposing a small block of wood between the v and the valve chamber cap or by holding the valve hea the seat with a screw-driver or other tool. The valve spr shown at D has the important advantage of keeping head firmly pressed against the seat at the same time valve spring cap or collar is lifted. This consists of a ca lever of peculiar shape provided with notches to enga chain. One end of the jack chain is attached to a hook intended to bear down against the valve head. Anot in which the hook principle is carried out is shown at consists of a frame bar having a series of holes at its l designed to fit the fulcrum pin of the valve spring liftin

Another application of the screw form of valve spr is shown at F. This consists of a main portion or f *having the upper* end threaded to fit the T-handle screw

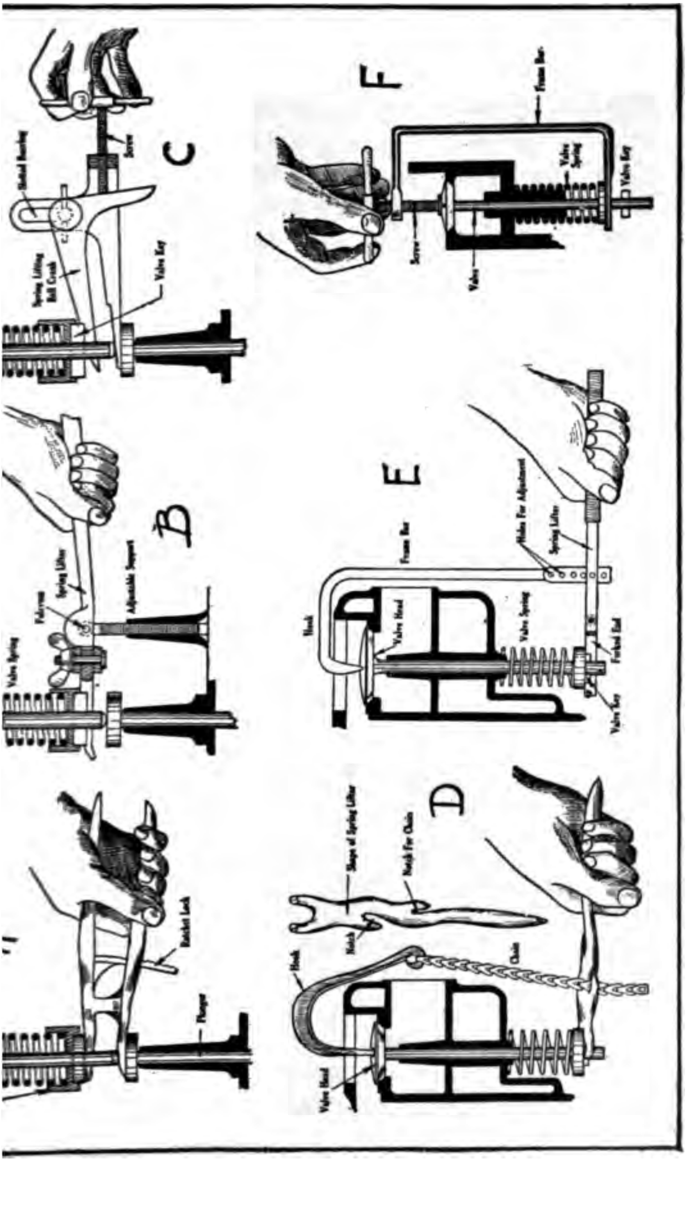


Fig. 113.—Application of Valve Spring Compressing Tool to Permit Removal of Valve Stem Keys.

lower end is in the form of a yoke to straddle the valve stem an(lift the valve spring collar. This is a very efficient form and ha the advantage of keeping the spring compressed as long as de sired, permitting ready removal of the valve key, which is a advantage not possessed by the lever form in which one hand mus be used at the lever end while the other is depended on to remov the key. With the valve spring lifter shown at A, C and F, botl hands may be used for the work, as the devices will keep th spring compressed as long as desired. The construction is s clearly shown that any one of the valve spring lifters outline may be readily duplicated by the repairman at slight expense.

An ingenious method of keeping a valve spring compresse while the key is extracted from the stem is shown at Fig. 114, A A piece of iron pipe is cut of such length that two pieces may b obtained by cutting the pipe longitudinally in half. The longes of these pieces is of such height as is necessary to raise the valv spring collar sufficiently high to free it entirely from the key The other piece is shorter. In operation the valve lift plunger i raised by its cam as shown at A 1. This permits one to introduc the short piece of pipe between the crankcase and the valve sprin collar. The camshaft is then rotated until the plunger returns t the lower end of its stroke again. A wide space then exists be tween the end of the valve stem and the top of the plunger. piece equal to the difference in height between the short pipe show at A 1 and the long piece of pipe shown at A 3 is then inserte to fill this space between the valve stem and plunger. The can shaft is again rocked or turned sufficiently so the cam again rais the valve plunger. This brings the valve spring collar still highe and permits one to insert the long piece of pipe as at A 3. Whe the valve head is pushed down on its seat the key is readily a cessible, and may be easily removed with a small pair of pliers.

The special valve spring lifter furnished for Ford repairme has been previously outlined. The method of using it is show at Fig. 114, B. The construction of a simple valve spring lifte that can be used on two valves at a time is shown at C. This co sists of a forked casting adapted to bear on the valve plunger guid tops and carrying a steel stud at its center. The member designe

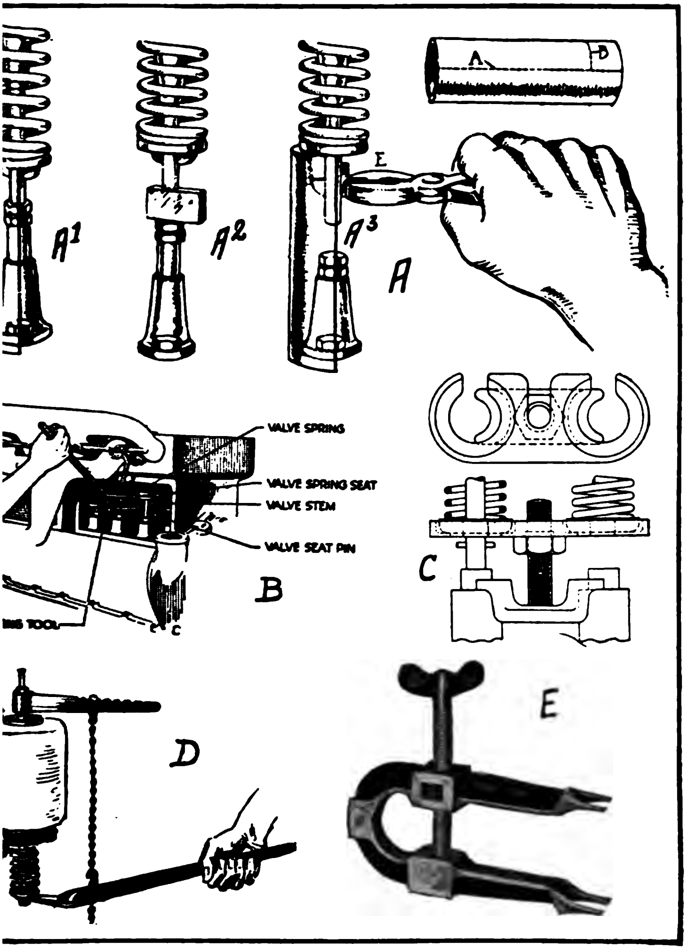


Fig. 114.—Valve Spring Lifting Tools of Varied Design.

e the valve spring collar is also a casting of such form ted in the plan view at C. This has three slots making it to insert it easily between the valve spring collar and the ng through the valve stem. If one screws up on the lift- it is apparent that *the valve spring* will be compressed

and the pins passing through the valve stem may be easily re moved. This device is especially adapted for use on Ford motors The Winsor valve spring lifter shown at D is a modification of th form shown at Fig. 113, E. The arm on which the supportin chain is hooked is carried by a bolt adapted to screw into th spark plug hole in the valve chamber cap. This carries a bol through its center which may be screwed down to hold the valv head securely against the seat. Under these conditions it is no difficult to raise the valve spring collar with the lever provide for the purpose and extract the spring retaining key or pin. A double forked form of valve spring lifter known as the "Uni versal" is shown at Fig. 114, E. This works on the same principl as that shown at Fig. 113, A, a screw being used to spread th ends which are forked to fit around the valve stem and the valv lift plunger respectively.

When the cylinder is of the valve in-the-head form, the metho of valve removal will depend entirely upon the system of cylinde construction followed. In the Knox cylinder shown at Fig. 10 it is possible to remove the head from the individual cylinde castings and the valve springs may be easily compressed by an suitable means when the cylinder head is placed on the work benc where it can be easily worked on. The usual method is to plac the head on a soft cloth with the valves bearing against th bench. The valve springs may then be easily pushed down wit a simple forked lever and the valve stem key removed to releas the valve spring collar. In the Franklin engine, which is show in part section at Fig. 115, it is not possible to remove the valve without taking the cylinder off the crank case, because the valv seats are machined directly in the cylinder head and the valv domes are cast integrally with the cylinder. This means that i the valves need grinding the cylinder must be removed from th engine base to provide access to the valve heads which are insid of that member, and which cannot be reached from the outsid as is true of the L- or T-cylinder construction.

The preferred method of carrying the valves when they ar placed in the cylinder head is shown at Fig. 116, which is a par sectional view of the Buick 6-cylinder motor. The valves are ca

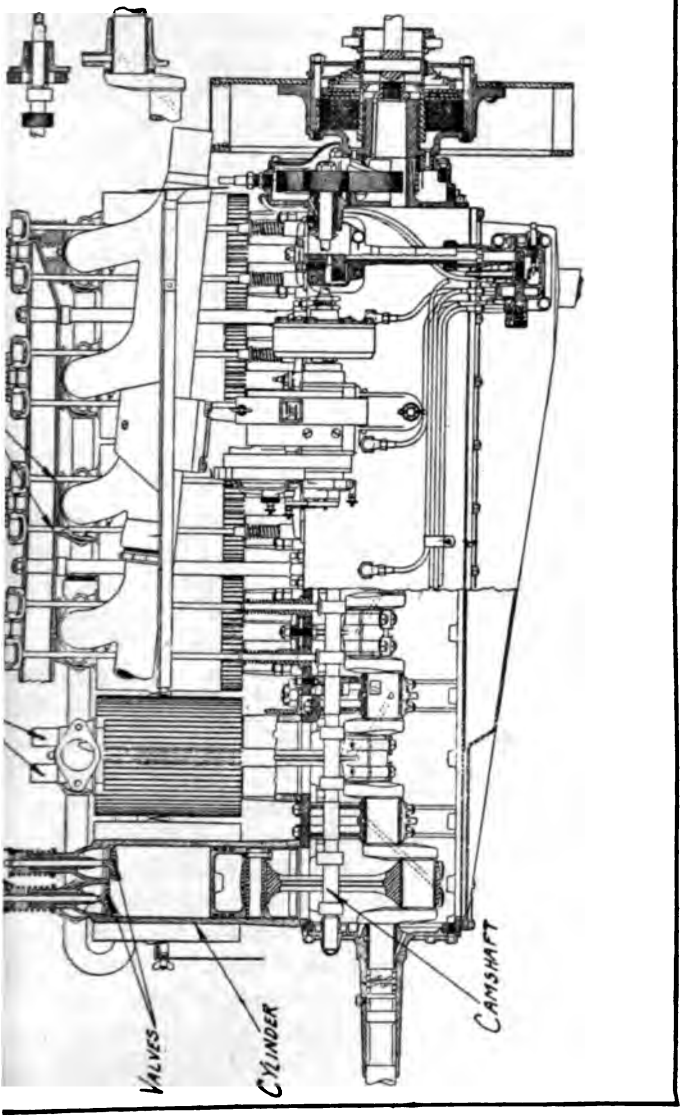


Fig. 115.—Part Sectional View of the Franklin Six Cylinder Air Cooled Engine, Showing Unconventional Valve Installation.

ried in cages which are readily removed from the cylinder hea by unscrewing the retention nut that keeps the valve cage tight pressed against the seating at its lower end to obtain a gas-tig joint. The valve cages are easy to handle and it is a relativel simple operation to compress the valve spring and remove the pi which makes for easy removal of the valve. When this constru tion is followed it is possible to grind in the valve by simply r moving the cage assemblies from the cylinder. It is not necessa to disturb the cylinder in any way and does not call for disco nection of intake or exhaust manifolds; the only things that ne be removed are the valve operating tappets, which is work of b a few moments.

The detachable head idea has been carried out in a distincti manner on the Premier-Weidely motor, which is shown in pa section at A, Fig. 117. In this the valves seat directly into t cylinder head member which serves six cylinders. This constru tion is made possible by casting the six cylinders in a block a using the type of cylinder head packing made popular by Ford car. The valves are operated by an overhead camshaft wh depresses the valve stems through the medium of a cam ri which relieves the valve stem of the side thrust which would present if the cam worked directly against the end of the va stem. In order to remove the valve with this construction i necessary to dismount the camshaft and cam riders which shown at B, in order to expose the valve spring collars as i cated at D. The entire cylinder head may be tilted up on bench as shown at C, which gives ready access to the valves w are provided with a slotted boss making it possible to turn t with a screw-driver bit when grinding them to a correct sea It is evident that the valves cannot be worked on without moving the cylinder head from the cylinder block casting.

Reseating and Truing Valves.—Much has been said rela to valve grinding, and despite the mass of information give the trade prints it is rather amusing to watch the average re man or the motorist who prides himself on maintaining his car performing this essential operation. The common mi *are attempting to* seat a badly grooved or pitted valve hea

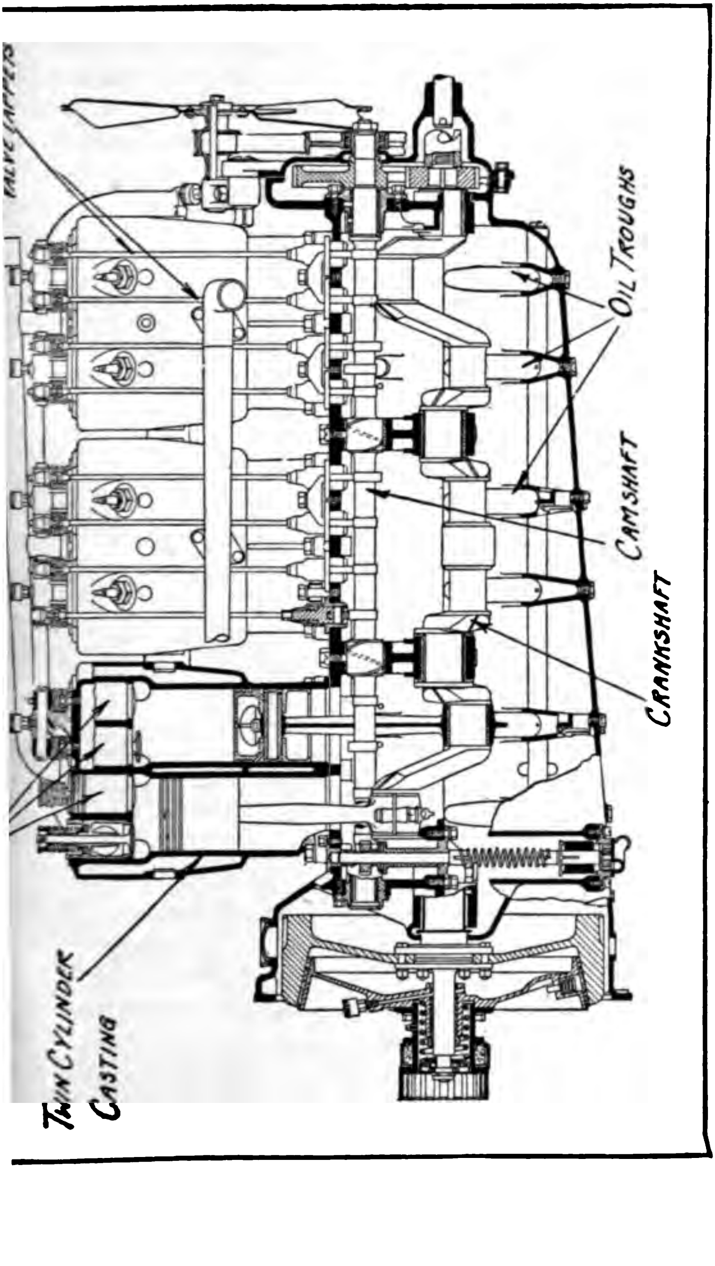


Fig. 116.—Part Sectional View of Six Cylinder Buick Motor, Showing Method of Valve Mounting in Easily Removable Valve Cages.

equally bad seat, which is an almost hopeless job, and of u coarse emery and bearing down with all one's weight on grinding tool with the hope of quickly wearing away the ro surfaces. The use of improper abrasive material is a fertile ca of failure to obtain a satisfactory seating. Valve grinding is a difficult operation if certain precautions are taken before un taking the work. The most important of these is to ascert

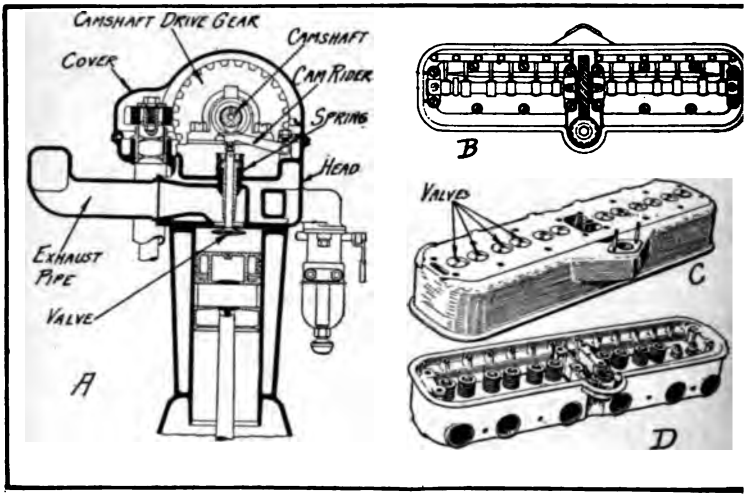


Fig. 117.—Sectional View Showing Construction of Premier-Weid Overhead Valve, Detachable Cylinder Head Motor.

if the valve head or seat is badly scored or pitted. If such is fou to be the cause no ordinary amount of grinding will serve restore the surfaces. In this event the best thing to do is remove the valve from its seating and to smooth down both valve head and the seat in the cylinder before attempt is m to fit them together by grinding. Another important precaut is to make sure that the valve stem is straight, and that the h is not warped out of shape or loose on the stem when the va is a two-piece member.

A number of simple tools is available at the present time

reseating valves, these being outlined at Fig. 118. That shown at A is a simple fixture for facing off the valve head. The stem is supported by suitable bearings carried by the body or shank of the tool, and the head is turned against an angularly disposed cutter which is set for the proper valve seat angle. The valve head is turned by a screw-driver, the amount of stock removed from the head depending upon the location of the adjusting screw. Care must be taken not to remove too much metal, only enough being taken off to remove the most of the roughness. Valves are made in two standard tapers, the angle being either 45 or 60 degrees. It is imperative that the cutter blade be set correctly in order that the bevel is not changed. A set of valve truing and valve-seat reaming cutters is shown at Fig. 118, B. This is adaptable to various size valve heads, as the cutter blade D may be moved to correspond to the size of the valve head being trued up. These cutter blades are made of tool steel and have a bevel at each end, one at 45 degrees, the other at 60 degrees. The valve seat reamer shown at G will take any one of the heads shown at F. It will also take any one of the guide bars shown at H. The function of the guide bars is to fit the valve stem bearing in order to locate the reamer accurately and to insure that the valve seat is machined concentrically with its normal center. Another form of valve seat reamer and a special wrench used to turn it is shown at C. The valve head truer shown at Fig. 118, D, is intended to be placed in a vise and is adaptable to a variety of valve head sizes. The smaller valves merely fit deeper in the conical depression. The cutter blade is adjustable and the valve stem is supported by a simple self-centering bearing. In operation it is intended that the valve stem, which protrudes through the lower portion of the guide bearing, shall be turned by a drill press or bit stock while the valve head is set against the cutter by pressure of a pad carried at the end of a feed screw which is supported by a hinged bridge member. This can be swung out of place as indicated to permit placing the valve head against the cutter or removing it.

As the sizes of valve heads and stems vary considerably a "Universal" valve head truing tool must have some simple means of centering the valve stem in order to insure concentric machining

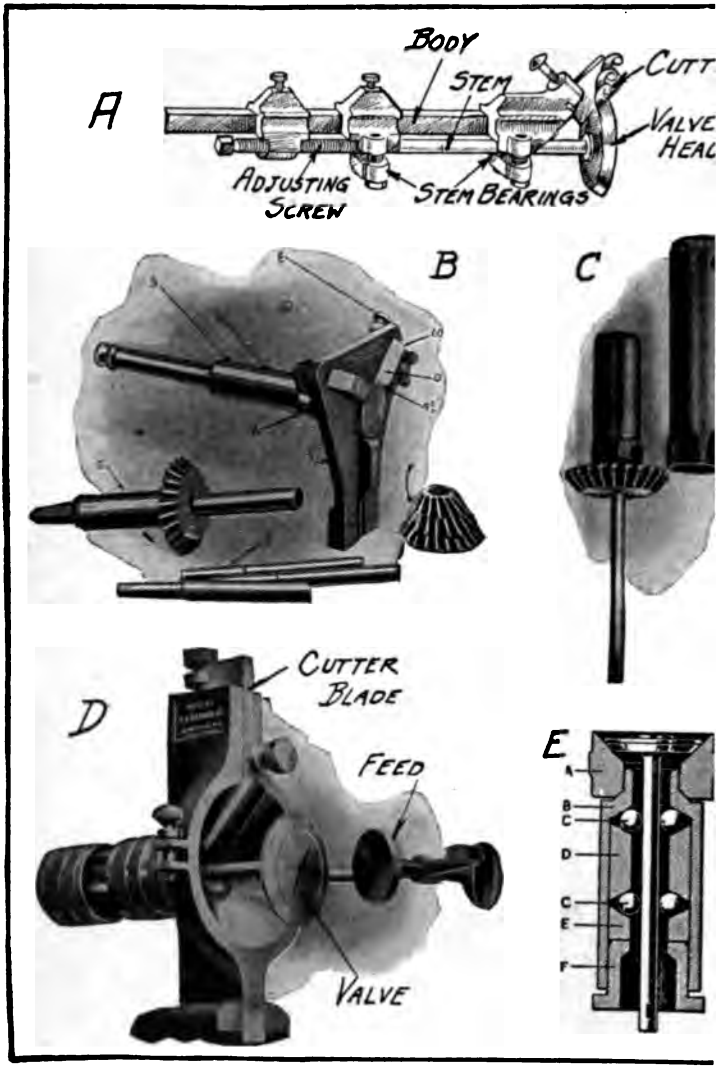


Fig. 118.—Tools for Restoring Valve Head and Seats.

of the valve head. A valve head truer which employs an ingenio method of guiding the valve stem is shown at Fig. 118, E. Tl device consists of a body portion B, provided with an extern thread at the top on which the cutter head A, is screwed. number of steel balls C, are carried in the grooves which ma be altered in size by the adjustment nut F, which screws in tl bottom of the body portion B. As the nut F is screwed in again the spacer member E, the V-grooves are reduced in size and tl steel balls C are pressed out in contact with the valve stem. As tl circle or annulus is filled with balls in both upper and lower portio the stem may be readily turned because it is virtually support by ball bearing guides. When a larger valve stem is to be su ported, the adjusting nut F, is screwed out which increases tl size of the grooves and permits the balls C, to spread out ar allow the larger stem to be inserted.

In straightening a spindle, light shaft or valve stem that h accidentally become bent, hammering the piece straight is cru and unmechanical and usually results in bruising it. A bett way to straighten a bent valve stem is shown in the illustratio at Fig. 119. The part to be straightened, in this case an exhau valve, should first be heated at the bent portion with a flame fro a blow torch which is deflected against the portion to be rais to a high temperature by a simple band iron fixture to locali the flame. This is indicated at A, and the method of using it shown at B. While the bend is still hot the valve stem is plac between the jaws of a strongly built vise as shown at C. Cut file V-shape notches in three nuts or other pieces of metal, l the bent piece between the jaws with one of the nuts under t bent portion and the other two spaced further apart as indicate Apply steady pressure with the vise screw and the piece w spring back into shape. By moving the supporting blocks N fro one portion of the valve stem to the other, always exerting pr sure against the bent part or high spot with one of the nu it will be possible to straighten the stem by removing kin at all points. While it is preferable to support the valve in lat centers to determine when it is accurately straightened, if a lat is not available a *simple frame as shown* at D, in which nails

used as centers in upright blocks of wood may be extem]
The valve is swung around and the high portions are in
with a piece of chalk.

The use of a clamp to straighten the valve stem is sh
D-2, this being suggested for use where a vise is not a\
A stiff metal piece is laid on top of the clamp screw and t
porting blocks are placed on it to keep the valve in place.
of soft sheet metal such as brass or copper is interposed l

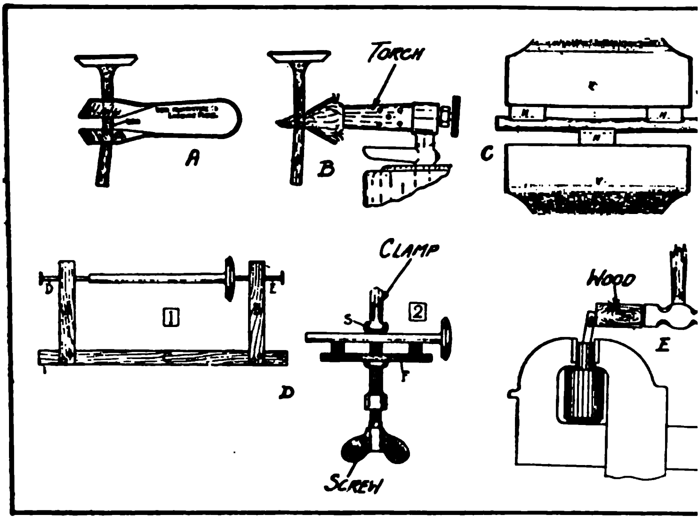


Fig. 119.—Simple Methods of Straightening Bent Valve St

the fixed end of the clamp and the valve stem in order not
that member. The method of straightening a bent valve
order to permit the removal of that member when it is
in a removable valve cage is shown at Fig. 119, E. If
tempts to press or drive the valve out when the stem stic
being bent the valve stem guide is apt to be broken, be
is of cast iron which is a brittle material that will not sta
stresses.

In straightening the valve the vise jaws are provided \
metal cap pieces and the cast iron valve stem guide i

gripped between these members. When supported in this manne there is no danger of breaking off the boss and the stem ma be straightened by blows from the hammer, taking care to interpos a block of hard wood or a piece of babbitt metal between th valve stem and the hammer. When the valve cage is placed in th vise care will be taken to have the bent portion of the stem at th end of the hub and it will also be important to have the valve stem so inclined that the blows directed against it will be exerted alon the longitudinal center line of the vise. The valve stems ar often bent when a wrench used to remove the cages slips an strikes the valve stem. The repairman may consider the wor sufficiently well done when the stem has been so straightened tha the valve will fall out of the cage of its own weight. It is eviden that the hammer blows must be carefully directed and that th force of these be gauged intelligently as it is better to do th straightening with a series of light blows than with a lesse number of heavy ones which may cause damage.

Valve Grinding Processes.—Mention has been previously mad of the importance of truing both valve head and seat before at tempt is made to refit the parts by grinding. The appearance c a valve head when pitted or scored is indicated at Fig. 120, A in order that the motorist or novice repairman can readily identif this defective condition. After smoothing the valve seat the nex step is to find some way of turning the valve. Valve heads ar usually provided with a screw driver slot passing through th boss at the top of the valve or with two drilled holes to take forked grinding tool. The method of arranging the valve hea for the grinding tool and the types of grinding tools commonl used are also shown at Fig. 120, A. A combination grinding to which may be used when either the two drilled holes or the slotte head form of valve is to be rotated is shown at Fig. 120, B. Th consists of a special form of screw driver having an enlarged bo just above the blade, this boss serving to support a U-shape pie which can be securely held in operative position by the clam screw or which can be turned out of the way if the screw driv blade is to be used.

As it is desirable to turn the valve through a portion of a re

lution and back again rather than turning it always in the direction, a number of special tools has been designed to this oscillating motion possible without trouble. A simple grinding tool is shown at Fig. 120, C. This consists of a driver blade mounted in a handle in such a way that the end turn freely in the handle. A pinion is securely fastened t screw driver blade shank, and is adapted to fit a race provided a wood handle and guided by a bent bearing member sec fastened to the screw driver handle. As the rack is pushed and forth the pinion must be turned first in one direction and in the other.

A valve grinding tool patterned largely after a breast is shown at Fig. 120, D. This is worked in such a manner t continuous rotation of the operating crank will result in an lating movement of the chuck carrying the screw driver l The bevel pinions which are used to turn the chuck are nor free unless clutched to the chuck stem by the sliding sleeve must turn with the chuck stem and which carries clutching bers at each end to engage similar members on the bevel pi and lock these to the chuck stem, one at a time. The bevel carries a cam piece which moves the clutch sleeve back and as it revolves. This means that the pinion giving forward m of the chuck is clutched to the chuck spindle for a portion revolution of the gear and clutch sleeve is moved back by the and clutched to the pinion giving a reverse motion of the c during the remainder of the main drive gear revolution.

A method that can be used for smoothing the surface valve head when the usual form of valve head truer is not able is indicated at Fig. 120, E. The valve heads are us provided with a small depression in the center known as a cou sink which is designed to act as a support for the valve it is being machined from the forging. The stem of the val caught in the chuck of a bit stock and rested on any sharp on a wall or bench. This can be easily made by driving a wire nail in the bench from underneath so that the point pro through the bench. The bit stock is briskly turned by a h *and the rough spots* are removed from the seat with a fine file

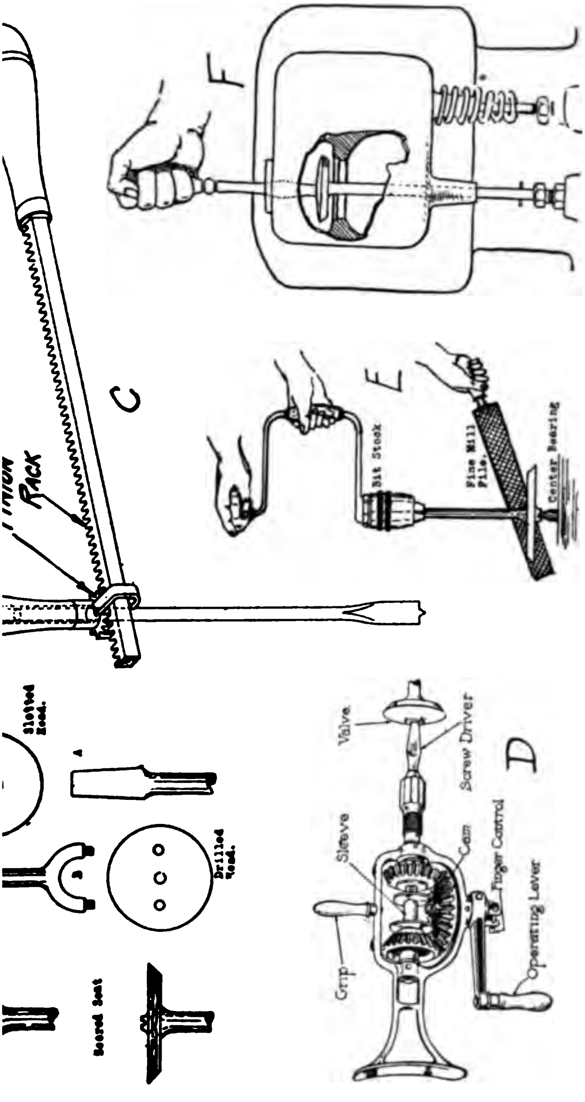


Fig. 120.—Forms of Valve Grinding Tools.

being taken not to change the taper of the valve head. Tl stem could be turned much faster and a superior finish obtai breast drill were used instead of a bit stock, though with very creditable job may be done with the latter.

One of the things to watch for in valve grinding is indicated at Fig. 120, F. It sometimes happens that the ac screw on the v plunger or th lift plunger its not permit th head to rest the seat. Wh condition is e ated in the sl will be appare unless a definit exists between of the valve st the valve lift that grinding of little avail the valve head bear properly the abrasive n smeared on th seat.

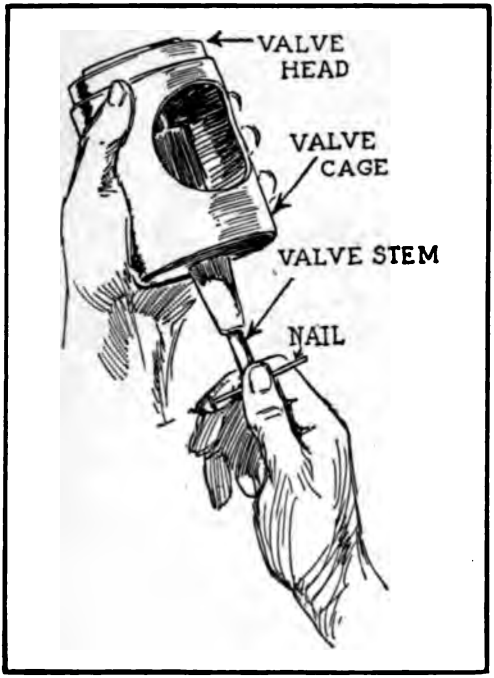


Fig. 121.—A Nail or Piece of Wire Only Tool Necessary for Grinding Buick Valves to Correct Seating in Cage.

The usual r of valve grind clearly outl Fig. 122. The the left shov method of turn valve by an ordinary screw driver and also shows a valve A, having both the drilled holes and the screw driver slot fc ing the member and two special forms of fork-end valve g tools. In the sectional view shown at the right, the use of tl *spring between the* valve head and the bottom of the valve c

:o lift the valve head from the seat whenever pressure on the grinding tool is released is clearly indicated. It will be noted also that a ball of waste or cloth is interposed in the passage between the valve chamber and the cylinder interior to prevent the abrasive material from passing into the cylinder from the valve chamber. When a bitstock is used, instead of being given a true rotary

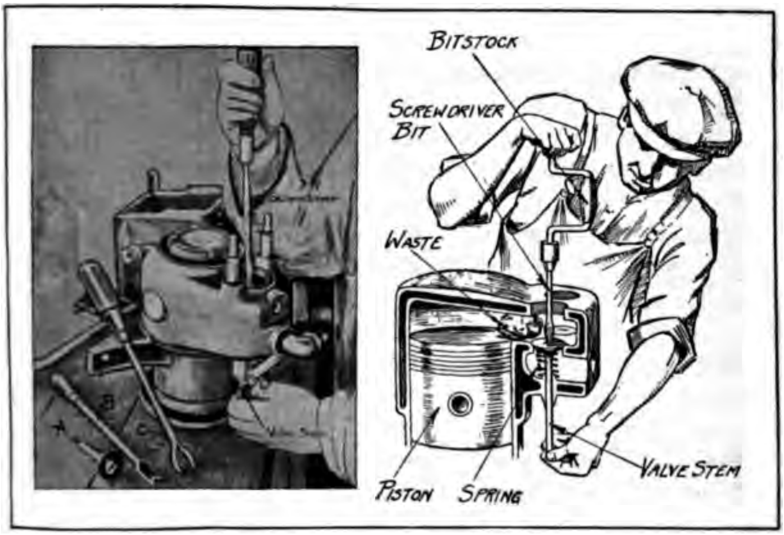


Fig. 122.—Showing Practical Methods of Valve Grinding. At Left, with Ordinary Screw Driver; at Right, with Screw Driver Bit and Bitstock.

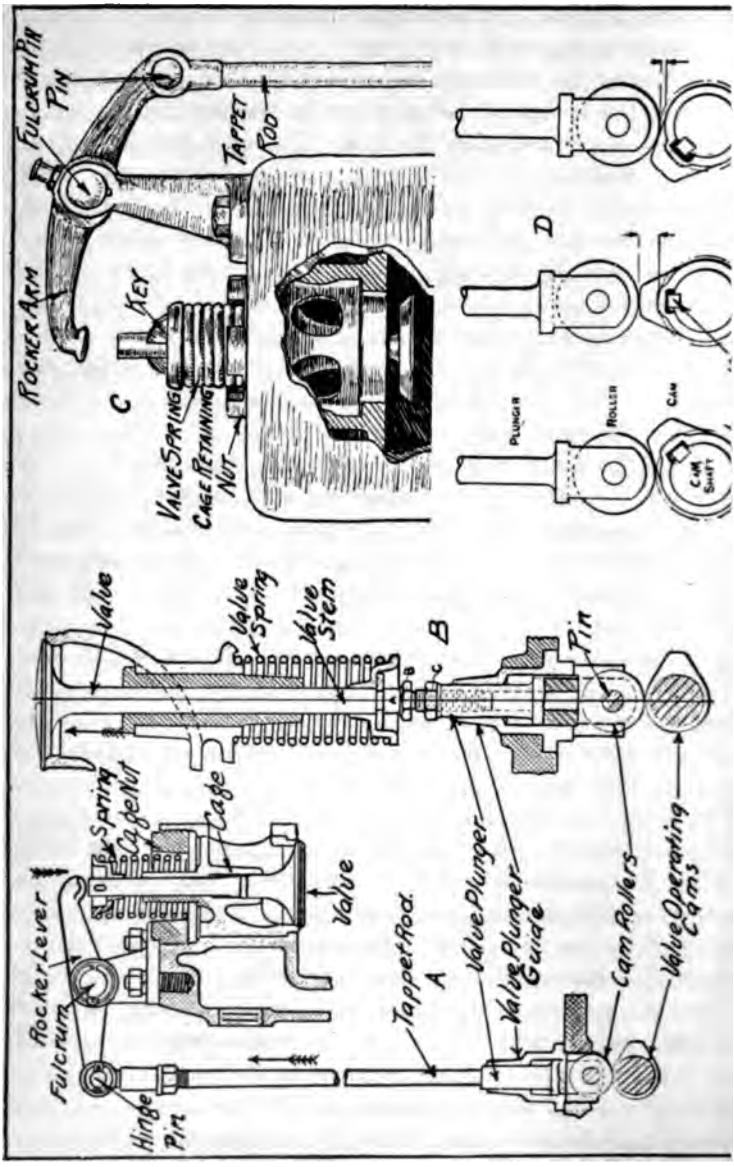
motion the chuck is merely oscillated through the greater part of the circle and back again. It is necessary to lift the valve from its seat frequently as the grinding operation continues, this s to provide an even distribution of the abrasive material placed between the valve head and its seat. Only sufficient pressure is given to the bitstock to overcome the uplift of the spring and to nsure that the valve will be held against the seat. Where the spring s not used it is possible to raise the valve from time to time with he hand which is placed under the valve stem to raise it as the rinding is *carried on. It is not always* possible to lift the valve

in this manner when the cylinders are in place on the engine base owing to the space between the valve lift plunger and the end of the valve stem. In this event the use of the spring as shown in sectional view will be desirable.

The abrasive generally used is a paste made of medium or fine emery and lard, oil or kerosene. This is used until the surfaces are comparatively smooth, after which the final polish or finish is given with a paste of flour emery, grindstone dust, crocus, or ground glass and oil. An erroneous impression prevails in some quarters that the valve head surface and the seating must have a mirror-like polish. While this is not necessary it is essential that the seat in the cylinder and the bevel surface of the head be smooth and free from pits or scratches at the completion of the operation. All traces of the emery and oil should be thoroughly washed out of the valve chamber with gasoline before the valve mechanism is assembled and in fact it is advisable to remove the old grinding compound at regular intervals, wash the seat thoroughly and supply fresh material as the process is in progress. The truth of seating may be tested by taking some Prussian blue pigment and spreading a thin film of it over the valve seat. The valve is dropped in place and is given about one-eighth turn with a little pressure on the tool. If the seating is good both valve head and seat will be covered uniformly with color. If high spots exist, the heavy deposit of color will show these while the low spots will be made evident because of the lack of pigment. The grinding process should be continued until the test shows an even bearing of the valve head at all points of the cylinder seating. When the valves are held in cages it is possible to catch the cage in a vise and to turn the valve in any of the ways indicated. It is much easier to clean off the emery and oil and there is absolutely no danger of getting the abrasive material in the cylinder if the construction is such that the valve cage or cylinder head member carrying the valve can be removed from the cylinder. When valves are held in cages the tightness of the seat may be tested by partially filling the cage with gasoline and noticing how much liquid oozes out around the valve head. The degree of moisture present indicates the efficacy of *the grinding process.*

Depreciation in Valve Operating Systems.—There are a num ber of points to be watched in the valve operating system becau valve timing may be seriously interfered with if there is muc lost motion at the various bearing points in the valve lift mecha ism. The two conventional methods of opening valves are show at Fig. 123. That at A, is the type employed when the val cages are mounted directly in the head, while the form at B, the system used when the valves are located in a pocket or e tension of the cylinder casting as is the case if an L, or T-hea cylinder is used. It will be evident that there are several poin where depreciation may take place. The simplest form is th shown at B, and even on this there are five points where lost m tion may be noted. The periphery of the valve opening cam roller may be worn though this is not likely unless the roll or cam has been inadvertently left soft. The pin which acts a bearing for the roller may become worn, this occurring qui often. Looseness may materialize between the bearing surfac of the valve lift plunger and the plunger guide casting and the may also be excessive clearance between the top of the plung and the valve stem.

On the form shown at A, there are several parts added to tho indicated at B. A walking beam or rocker lever is necessary transform the upward motion of the tappet rod to a downwar motion of the valve stem. The pin on which this member fulcrun may wear as will also the other pin acting as a hinge or bearin for the yoke end of the tappet rod. It will be apparent that slight play existed at each of the points mentioned it might resu in a serious diminution of valve opening. Suppose, for exampl that there were .005-inch lost motion at each of three bearing point the total lost motion would be .015-inch or sufficient to produ noisy action of the valve mechanism. When valve plungers the adjustable form, such as shown at B, are used, the hardene bolt head in contact with the end of the valve stem may becom hollowed out on account of the hammering action at that poin It is imperative that the top of this member be ground off tr and the clearance between the valve stem and plunger properly a justed. If the plunger is a non-adjustable type it will be necessa


Fulcrum Pin
Pin
Rocker Arm
Key
Tappet Rod
C
Valve Spring
Cage Retaining Nut
D
Plunger
Roller
Cam
Cam Shaft
Valve
Valve Spring
Valve Stem
B
Pin
Spring
Cage Nut
Cage
Valve
Rocker Lever
Fulcrum
Hinge Pin
Tappet Rod.
A
Valve Plunger
Valve Plunger Guide
Cam Rollers
Valve Operating Cams

gthen the valve stem by some means in order to reduce :cessive clearance. The only remedy for wear at the various ; and bearing pins is to bore the holes out slightly larger fit new hardened steel pins of larger diameter. Depreciation :n the valve plunger guide and the valve plunger is usually ied by fitting new plunger guides in place of the worn ones. :re is sufficient stock in the plunger guide casting as is s the case when these members are not separable from the er casting, the guide may be bored out and bushed with a ›ronze bushing.

ıother point where depreciation must be looked for is be- the valve stem and the valve stem guide in the cylinder. ıethods of repairing this defect are clearly indicated at Fig. A common cause of irregular engine operation is due to a g valve, which condition is clearly depicted at Fig. 123, C. ıay be due to a bent valve stem, a weak or broken valve or an accumulation of burnt or gummed oil between the tem and the valve stem guide. In order to prevent this the tem must be smoothed with fine emery cloth and no burrs ılders allowed to remain on it, and the stem must also be t and at right angles to the valve head. If the spring is t may be strengthened in some cases by stretching it out so larger space will exist between the coils. Obviously if a is broken the only remedy is replacement of the defective r.

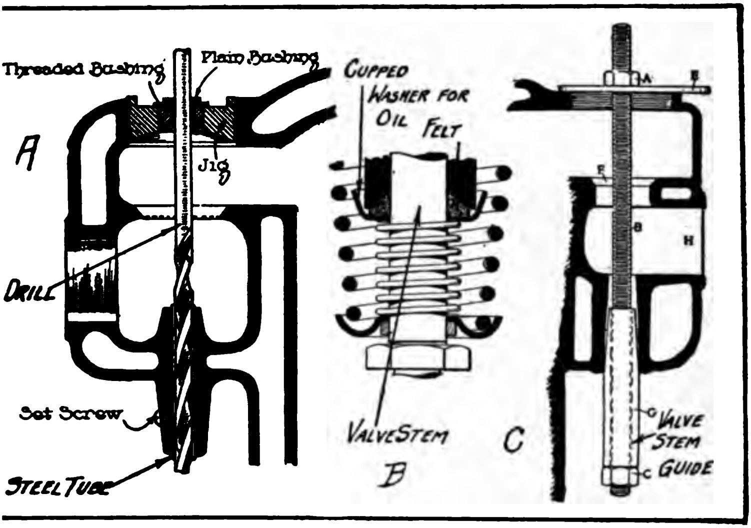
ıumber of engines of old patterns had cams keyed to the ıft instead of formed integrally with it as is now common e. After the engine had been used for a time, especially valve springs were stiff, the key was very apt to become ı the cam which would result in a pronounced knock when gine was in operation. The reason for this knock may be understood by referring to illustration at Fig. 123, D. With r slot worn, as the cam started to lift the plunger the pres- gainst the cam would cause that member to come back ; the key sharply and the hammering action would cause Similarly when the cam left the plunger the looseness again be evidenced and another knock would result. Where

this form of fastening is used the only remedy for worn key in the cam is to use wider keys in the camshaft by providing keyways in that member. While it is possible to cure the tro by using a two diameter key, this is not considered good pra owing to difficulties in properly fitting such a member.

Mention has been made of wear in the valve stem guide its influence on engine action. When these members are an inte part of the cylinder the only method of compensating for wear is to drill the guide out and fit a bushing, which ma made of steel tube. In order to insure that the hole will be b out true a simple jig is extemporized from one of the valve chai caps as indicated. The cap used is the member carrying spark plug and the opening left for this member is filled wi threaded bushing carrying a plain hardened steel bushing inte for the drill guide. As it is not always possible to procure tubing of the proper size it may be necessary to drill out or out the bore of the tube to fit the valve stem after the bus is driven in place.

In most engines, especially those of recent development, valve stem guide is driven into the cylinder casting and separate member which may be removed when worn and repl with a new one. When the guides become enlarged to such a p that considerable play exists between them and the valve stems, may be easily knocked out by using a drift pin of the proper and a hammer or forced out under an arbor press. This is a difficult thing to do, as one need not be afraid of injurin member which is no longer of any use. Care must be taken, h ever, in placing the new valve stem guide because, while this m be hammered in place, it could not be done unless extreme was exercised and there would always exist the possibility injuring the guide. The approved method of installing a valve stem guide is shown at Fig. 124, C. A cold rolled rod is threaded practically its entire length and is of suffic diameter to just fit into the hole in the guide. A substantial p of flat stock E, is placed over the valve chamber, this being at l one-quarter inch thick and one inch wide and of such len as to bridge the valve cap opening over and leave a liberal ma

either side. The nut A, is screwed down on the rod B, until nut C, at the lower end of the rod is bearing tightly against valve stem guide G. The guide member is then forced into ce by turning either or both of the nuts A, or C, until it irmly seated. It is possible to use a long bolt instead of the B, if desired. When this system of valve guide construction followed, the work of replacing the worn members can be



g. 124.—Practical Methods of Restoring Worn Valve Stem Guide Bushing.

ie by one without mechanical experience just as well as by the re expert.

The depreciation of the exposed valve stem guides may be uced considerably by adopting the scheme for lubricating the re stems shown at Fig. 124, E, used on Overland cars. This sists of cutting out the lower portion of the valve stem guide ake a beveled felt washer which is kept firmly pressed against seating by a cupped steel washer maintained in contact against felt by a coil spring extending down to the valve spring collar fitting the valve *stem fairly close.* The shape of the cupped

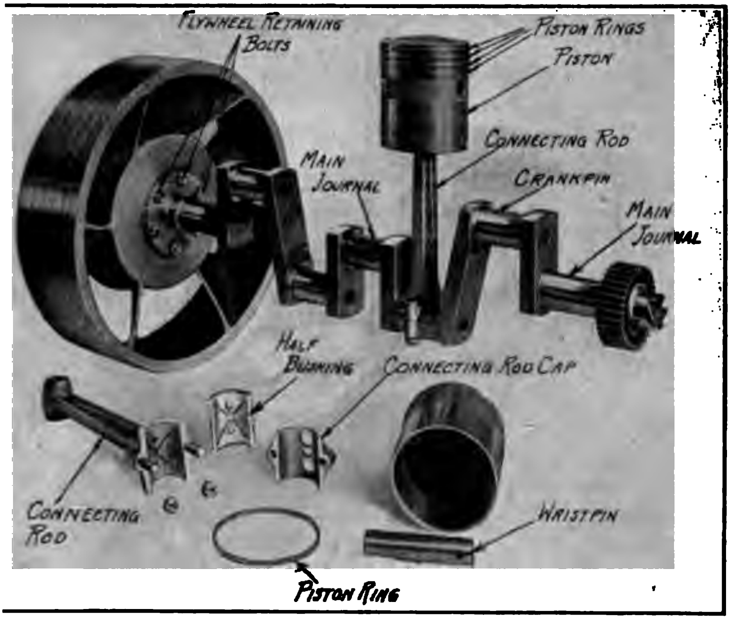
washer makes it possible to fill that member with oil whic absorbed by the felt and distributed against the valve stem reciprocates up and down. On practically all motors of re design, provision is made for enclosing the valve stems and plun in order to keep out dirt and grit and to retain lubricating splashed on the working surfaces from the crankcase int or forced out through the valve operating plunger guides bec of internal crankcase pressure.

Piston Troubles.—If an engine has been entirely dismantl is very easy to examine the pistons for deterioration. The rela of the piston, connecting rod and crankshaft of a typical p plant is clearly outlined at Fig. 125 and below the assembled both the connecting rod and piston are shown dismantled. W it is important that the piston be a good fit in the cylinder mainly upon the piston rings that compression depends. The should fit the cylinder with but little looseness, the usual p being to have the piston about .001-inch smaller than the for each inch of piston diameter at the point where the heat is present or at the bottom of the piston. It is neces allow more than this at the top of the piston owing to its sion due to the direct heat of the explosion. The clear usually graduated and a piston that would be .005-inch than the cylinder bore at the bottom would be about .00 at the middle and .0075-inch at the top. If much more pla this is evidenced the piston will "slap" in the cylinder piston will be worn at the ends more than in the center. P sometimes warp out of shape and are not truly cylindrical. results in the high spots rubbing on the cylinder while th spots will be blackened where a certain amount of gas has leak

Mention has been previously made of the necessity of re or regrinding a cylinder that has become scored or scratche which allows the gas to leak by the piston rings. When the cy is ground out, it is necessary to use a larger piston to conf the enlarged cylinder bore. Most manufacturers are prep furnish over-size pistons, there being four standard over- mensions adopted by the S. A. E. for rebored cylinders. are .010-inch, .020-inch, .030-inch, and .040-inch larger th

ır dimension. Care should be taken in reboring the cylinders ıere as closely as possible to one or the other of these stand-

the engine construction is such that side plates may be re- l from the crank case and the cylinder head removed from ·linders it is possible to remove a piston for inspection with-



125.—Typical Piston, Connecting Rod and Crankshaft Assembly.

aking down the entire motor. As will be noted at Fig. 126, the side plate is removed from the engine base a large open- s left through which the connecting rod cap nuts may be · reached with an ordinary S wrench. After the cap is re- d from the connecting rod it is not difficult to push the con- ıg rod and piston assembly out through the opening left at ›p of the cylinder.

ll gas engine pistons are provided with two or more packing *and it is these members that frequently need inspection,*

rather than the piston itself. The common forms of piston used are outlined at Fig. 127. The different types show fitted to one piston, though the usual practice is to use ri the same type in each group. The ring shown at Fig. 127, a diagonal cut joint and has been widely applied. That de at B, has a lapped or step joint, and is superior to the form above it, inasmuch as it will retain gas in a more positive m The butt joint ring shown at C, is seldom used on automob

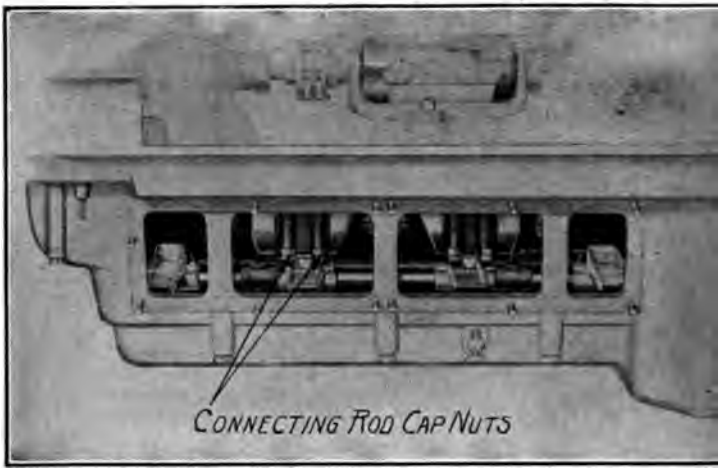


Fig. 126.—Showing how Connecting Rod Caps May be Reached Th Inspection Holes in the Side of the Crankcase.

gines though it is sometimes applied to cheap stationary or n types. The use of a number of light steel rings instead o wide ring in the groove is found on a number of the 1915 mobile power plants. It is contended that where a numb light rings is employed a more flexible packing means is obt and the possibility of leakage is reduced. Rings of this desig made of square section steel wire and are given a spring te Owing to the limited width the diagonal cut joint is generall ployed instead of the lap joint which is so popular on wider This construction is clearly outlined at Fig. 127, D.

***Leak Proof* Piston Rings.**—In order to reduce the co

sion loss and leakage of gas by the ordinary simple form of d agonal or lap joint one-piece piston ring a number of compoun rings have been devised and are offered to the repairman to us in making replacements. The leading forms are shown at Fig. 128. That shown at A, is known as the "Statite" and consists of three rings, one carried inside while the other two are carried on the outside. The ring shown at B, is a double ring and is known as the McCadden. This is composed of two thin concentric lap joint rings so disposed relative to each other that the opening in the inner ring comes opposite to the opening in the outer ring. The form shown at C is known as the "Leektite," and is a single ring provide with a peculiar form of lap and dove tail joint. The ring show at D, is known as the "Dunham" and is of the double concer tric type being composed of two rings with lap joints which ar welded together at a point opposite the joint so that there is n passage by which the gas can escape. The Burd high compres sion ring is shown at E. The joints of these rings are seale by means of an H shaped coupler of bronze which closes th opening. The ring ends are made with tongues which interloc with the coupling. The ring shown at F, is called the "Evertite and is a three-piece ring composed of three members as shown i *the sectional view below the ring.* The main part or inner ri

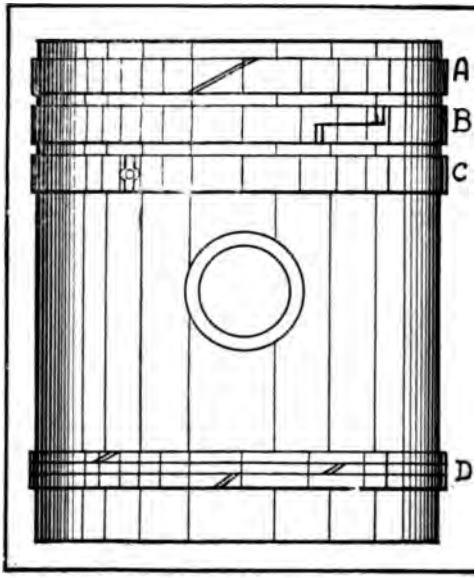


Fig. 127.—Forms of Piston Rings Commonl Used.

has a circumferential channel in which the two outer rings loc the resulting cross-section being rectangular just the same as th of a regular pattern ring. All three rings are diagonally spl and the joints are spaced equally and the distances maintained l small pins. This results in each joint being sealed by the sol portion of the other rings.

The piston rings should be taken out of the piston grooves aı all carbon deposits removed from the inside of the ring and tl

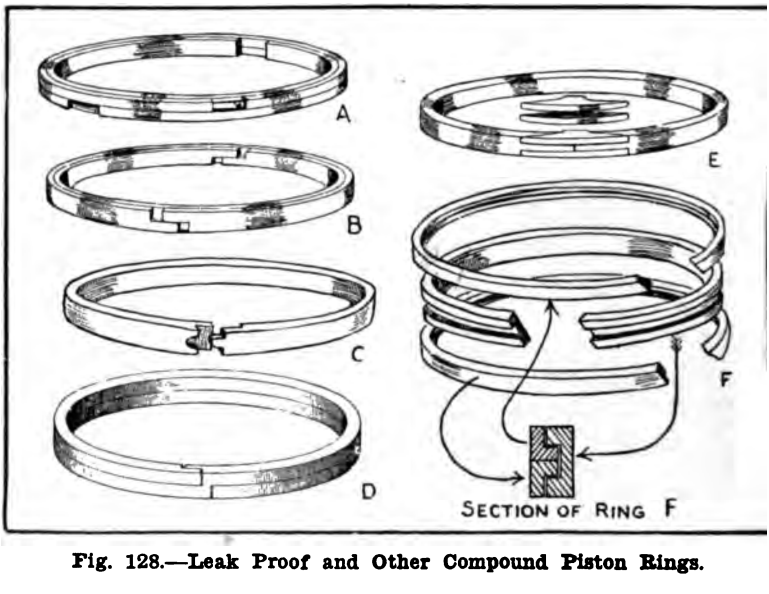
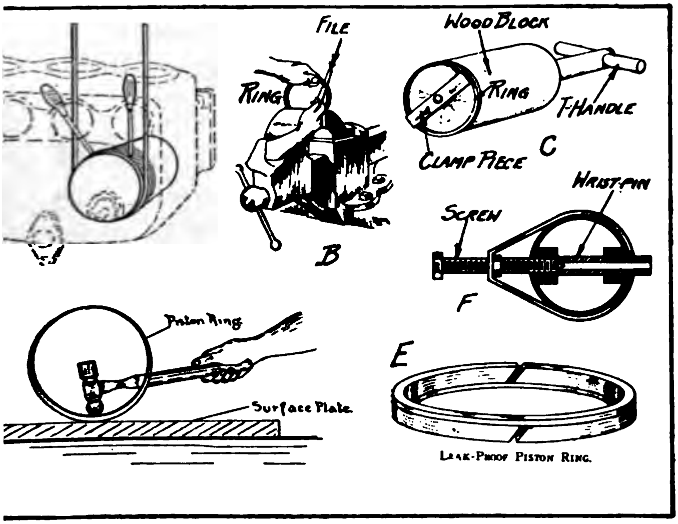


Fig. 128.—Leak Proof and Other Compound Piston Rings.

bottom of the groove. It is important to take this deposit out b cause it prevents the rings from performing their proper functioı by reducing the ring elasticity, and if the deposit is allowed t accumulate it may eventually result in sticking and binding (the ring, this producing excessive friction or loss of compressioı When the rings are removed they should be tested to see if the retain their elasticity and it is also well to see that the small piı in some pistons which keep the rings from turning around so tl *joints will not come* in line are still in place. If no pins are fouı

no cause for alarm because these dowels are not always 'hen fitted, they are utilized with rings having a butt joint ıal cut as the superior gas retaining qualities of the lap ›int render the pins unnecessary.

; has been blowing by the ring or if these members have fitting the cylinder properly the points where the gas :ll be evidenced by burnt, brown or roughened portions



. 129.—**Processes Incidental to P:stcn Ring Restoration.**

ished surface of the pistons and rings. The point where loration will be noticed more often is at the thin end of ric ring, the discoloration being present for about ½-inch ı each side of the slot. It may be possible that the rings true when first put in. This made it possible for the ık by in small amounts initially which increased due to pressure until quite a large area for gas escape had ted.

ring Pistons Stuck in Combustion Chamber.—The re- d replacement of *pistons and rings* seldom offer any

trouble if the work is properly carried on, but if for any the piston should be pushed too far up into the cylinder or types of engines the top ring will expand into the combustion ber and will lock the pistons tightly in place. This is a d condition to overcome with some forms of cylinders though cylinder casting is of the L or T form it may be possible to press the rings sufficiently to remove the piston by simple

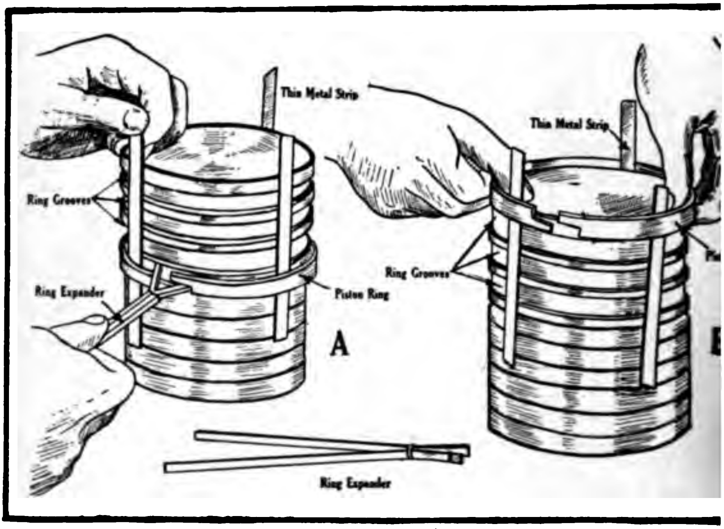
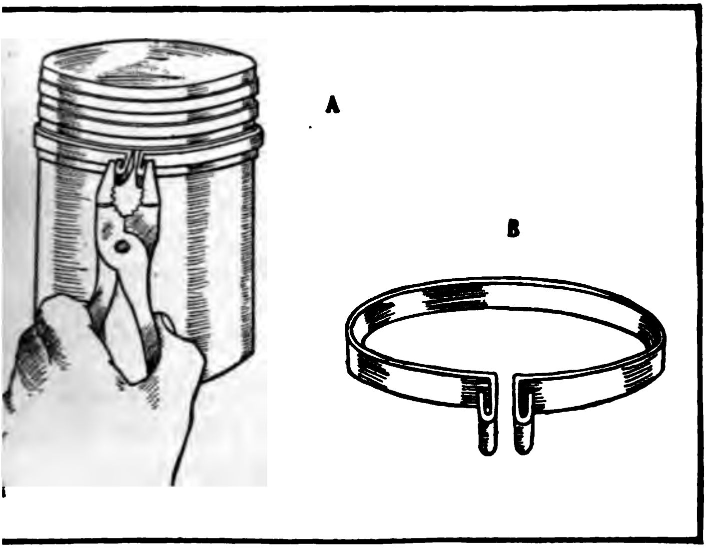


Fig. 130.—Simple Method of Removing or Installing Piston Rin

The best method is shown at Fig. 129, A. A very thin st metal of approximately the same width as the piston rings is through one of the valve chamber openings and passed arou piston and pulled out through the other opening. It requir services of two people and sometimes three to remove a pisto in this manner. The efforts of one are directed to keep th taut under the ring and to exert an upward pull which for portion of the ring embraced by the metal band to fill the in the piston. Another person uses a pair of screw driv *through each* valve chamber opening to compress the rir

indicated in the drawing. This means that a three point
ssional effect is obtained and it is a simple matter for the
person to draw the piston back into the cylinder when the
as been properly compressed in its groove. It is not always
e to compress the ring so the only other alternative is to
it in a number of pieces by hitting the brittle ring with a
r chisel and then withdrawing the pieces one at a time until



1.—Simple Clamp for Closing Piston Ring to Facilitate Insertion in Cylinders.

g has been entirely removed. With the T-head cylinder it
times possible to remove the ring without the use of the
ands, as that member is compressed at diametrically op-
points by a screw driver inserted through each valve cham-
.

on Ring Manipulation.—Removing piston rings is a dif-
peration if the proper means are not taken, but is a
atively simple one when the trick is known. The tools
d are very simple, being *three strips* of thin steel about

one-quarter inch wide and four or five inches long and a of spreading tongs made up of one-quarter inch diameter stock tied in the center with a copper wire to form a hinge. construction is such that when the hand is closed and the han brought together the other end of the expander spreads out, action just opposite to that of the conventional pliers. The met of using the tongs and the metal strips is clearly indicated Fig. 130. At A the ring expander is shown spreading the of the rings sufficiently to insert the pieces of sheet metal tween one of the rings and the piston. Grasp the ring as sh at B, pressing with the thumbs on the top of the piston the ring will slide off easily, the thin metal strips acting as g members to prevent the ring from catching in the other pi grooves. Usually no difficulty is experienced in removing the or bottom rings, as these members may be easily expanded worked off directly without the use of a metal strip. Whe moving the intermediate rings, however, the metal strips wi found very useful. These are usually made by the repai by grinding the teeth from old hacksaw blades and roundin edges and corners in order to reduce the liability of cuttin fingers. By the use of the three metal strips a ring is re without breaking or distorting it and practically no time is sumed in the operation.

Fitting Piston Rings.—Before installing new rings, they sh be carefully fitted to the grooves to which they are applied. tools required are a large piece of fine emery cloth, a thin, flat small vise with copper or leaden jaw clips, and a smooth har face such as that afforded by the top of a surface plate or a planed piece of hard wood. After making sure that all depo burnt oil and carbon have been removed from the piston gr three rings are selected, one for each groove. The ring is tur around its circumference into the groove it is to fit, which done without springing it over the piston as the outside edge ring may be used to test the width of the groove just as well inside edge. The ring should be a fair fit and while free t circumferentially there should be no appreciable up and *motion.* If the ring is a tight fit it should be laid edge do

ee of emery cloth which is placed on the surface plate and ly rubbed down until it fits the groove it is to occupy. It sable to fit each piston ring individually and to mark them e way to insure that they will be placed in the groove to they are fitted.

e repairman next turns his attention to fitting the ring in linder itself. The ring should be pushed into the cylinder it two inches up from the bottom and endeavor should be to have the lower edge of the ring parallel with the bottom cylinder. If the ring is not of correct diameter, but is y larger than the cylinder bore, this condition will be evi-y the angular slots of the rings being out of line or by diffi-in inserting the ring if it is a lap joint form. If such is se the ring is removed from the cylinder and placed in the etween the soft metal jaw clips, as shown at Fig. 129, B. ent metal is removed with a fine file from the edges of the t the slot until the edges come into line and a slight space between them when the ring is placed into the cylinder. It ortant that this space be left between the ends, for if this done when the ring becomes heated the expansion of metal use the ends to abut and the ring to jam in the cylinder.

other method of fitting a piston ring is indicated at Fig. !. A plug is made of soft wood, such as yellow pine that will easy fit in the cylinder and one end is turned down enough t a shoulder will be formed to back the ring. The turned portion should be a little less than the width of the ring to ted. The ring is pushed on this turned down end of the n plug and held by a small batten secured by a screw in the . This does not hold the ring tightly enough to keep it losing up. It is also important to turn the end of the wooden mall enough so that its diameter will be less than the bore ring when that member is tightly closed. The cylinder bore ared with a little Prussian blue pigment which is spread r over the cylinder wall with a piece of waste and the ring ed back and forth in the cylinder while it is held square e shoulder on the plug. The high spots on the ring will be l by color. Usually the *ring will be found* to bear hardest

at each side of the slot. These high spots are removed caref with a very fine mill file or piece of emery cloth and the ring again inserted in the cylinder bore to find other high spots wh are removed in a similar manner. When the rings fit fai well all around, the entire surface will have a uniform coat of blue.

If the old piston rings are bright all around but appear have lost their elasticity, a new lease of life may be given b process known as peening which is shown at Fig. 129, D. ring is stood on a surface plate and is tapped inside with the p end of a light hammer, using the harder blows at the thick sec and gradually reducing the force of the blow as the slot is proached. If skillfully done a ring may be stretched to some tent and considerable elasticity imparted. Piston rings are always of the simple form shown at Fig. 127. Various du constructions have been offered with an idea of reducing the p bility of leakage. A ring of this type which is known as the "I Proof" piston packing is shown at Fig. 129, E. These d rings are harder to install than the simpler forms, and it i portant that they be carefully fitted to the cylinder and to piston grooves.

It is necessary to use more than ordinary caution in repl the rings on the piston because they are usually made of cast a metal that is very fragile and liable to break because o brittleness. Special care should be taken in replacing new rin these members are more apt to break than old ones. This is ably accounted for by the heating action on used rings which to anneal the metal as well as making it less springy. The b ring should be placed in position first which is easily accomp by springing the ring open enough to pass on the piston then sliding it into place in the lower groove which on some of engines is below the wrist pin, whereas in others all groov above that member. The other members are put in by a re of the process outlined at Fig. 130. It is not always nec to use the guiding strips of metal when replacing rings a often possible, by putting the rings on the piston a little and manœuvering them to pass the grooves without spring

ring into them. The top ring should be the last one placed i position.

Before replacing pistons in the cylinder one should make sur that the slots in the piston rings are spaced equidistant on th piston and if pins are used to keep the ring from turning on should be careful to make sure that these pins fit into their hole in the ring and that they are not under the ring at any point Practically all cylinders are chamfered at the lower end to mak insertion of piston rings easier. The operation of putting on cylinder casting over a piston really requires two pairs of hands one to manipulate the cylinder, the other person to close the ring as they enter the cylinder. This may be done very easily by simple clamp member made of sheet brass or iron and used to clos the ring as indicated at Fig. 131, A. It is apparent that the clam which is shown at D, must be adjusted to each individual ring an that the split portion of the clamp must coincide with the spli portion of the ring. The cylinder should be well oiled before at tempt is made to install the pistons. The engine should be ru with more than the ordinary amount of lubricant for several day after new piston rings have been inserted. On first starting th engine, one may be disappointed in that the compression is eve less than that obtained with the old rings. This condition wil soon be remedied as the rings become polished and adapt themselve to the contour of the cylinder. It will take fully 100 miles of roa work to bring the rings to a sufficiently good fit so that a marke improvement in the compression will be noticed.

How Wrist Pins Are Held.—While the repairman is workin on the pistons there is one important member of the piston as sembly that should receive attention and that is the pin on whic the upper end of the connecting rod swings. These are held i place in a variety of ways, the most common of which are show at Fig. 132. In some forms of pistons the piston pin is a tight fi in the bosses and it is necessary to force it out. The method o doing this is clearly outlined at Fig. 129, F. This calls for th use of a special clamp fitting having a hole at one side sufficientl large for the wrist pin to pass through and carrying a forcin screw at the other. The screw passes through a nut which is ke

from turning by bending the band around it. Any motion of screw that will advance it into the nut will tend to force out wrist pin without injuring that member.

The means of locking the wrist pin in place that have been used are legion, but those depicted are the most common.

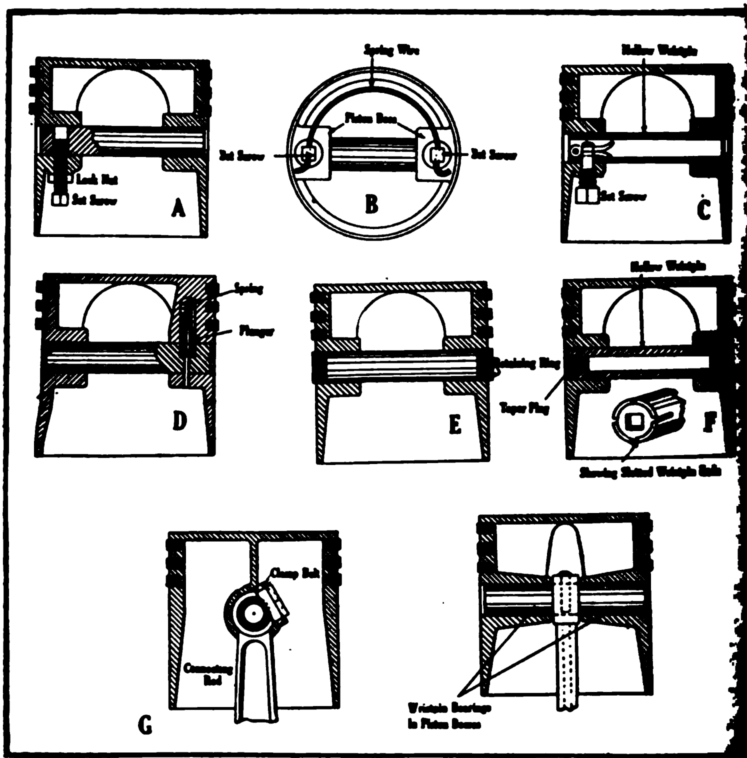


Fig. 132.—Conventional Methods of Piston Pin Retention.

at A, involves the use of a set screw passing through one of the piston bosses and into the wrist pin as indicated. This method is not the preferred construction on account of the liability of the lock nut to become loose and the set screw to unscrew itself by *vibration and* drop into the engine base where it may

iderable damage. When locking screws are employed, the methods f retention shown at B and C, are considered superior. In the ormer holes are drilled through the heads of the set screws and a iece of spring wire passed through them as indicated. Where a ollow wrist pin is used the end of the set screw may be provided with a hole to receive a split pin. The method of keeping the wrist pin in place shown at D, involves the use of a spring pressed plunger which is housed in a suitable boss cast on one side of the piston. In order to remove a wrist pin held by this method it is necessary to use a piece of stiff wire such as a bicycle spoke and to push the plunger back out of the wrist pin. The wrist pin is then moved slightly to one side so that the end of the plunger will rest on the wrist pin and the piece of stiff wire removed. It is then an easy matter to push the wrist pin out of the bosses. The method depicted at E, is self-explanatory, a retaining ring similar in construction to a piston ring, but somewhat wider passing entirely around the piston in a suitable groove cut around the zone of the wrist pin bosses. The method outlined at F, received wide application on earlier engines, but is not much used at the present time. In this the hollow wrist pin was slotted at four points at each end, and was provided with a tapering thread into which a correspondingly formed plug was screwed to expand the wrist pin against the bosses. In all of the forms outlined, the wrist pin is to be held from rotation while the connecting rod oscillates on it. In the form shown at G, the wrist pin oscillates in the piston bosses and the connecting rod is tightly clamped to the wrist pin by a suitable clamp bolt. To remove the wrist pin it is necessary to take out the clamp bolts which will permit the piston boss to spread enough to release its hold on the wrist pin.

Wrist Pin Wear.—While wrist pins are usually made of very tough steel, case hardened with the object of wearing out an easily renewable bronze bushing in the upper end of the connecting rod rather than the wrist pin it sometimes happens that these members will be worn so that even the replacement of a new bushing in the connecting rod will not reduce the lost motion and attendant noise due to a loose wrist pin. The only remedy is to fit new wrist pins to the *piston. Where the connecting* rod is clamped to the

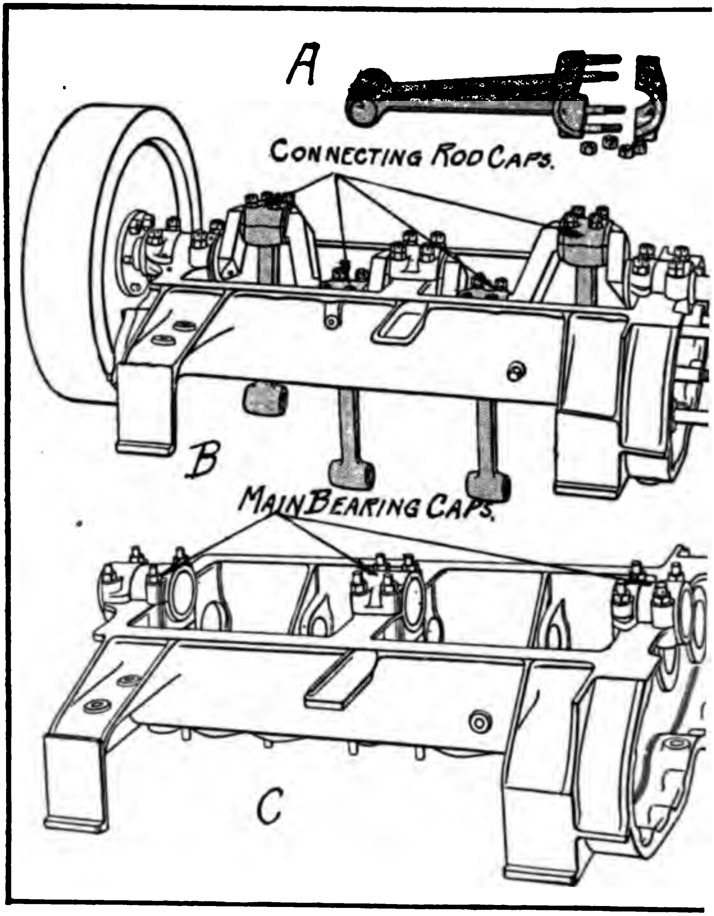
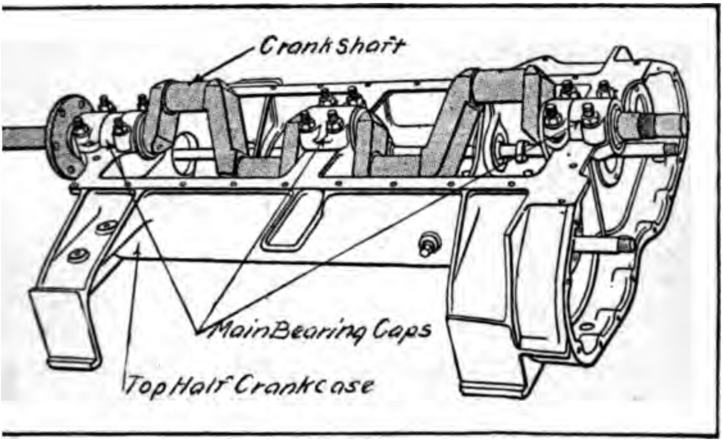


Fig. 133.—Showing Method of Supporting Crankcase to Provide Access to Connecting Rods and Crankshaft Bearings.

wrist pin and that member oscillates in the piston bosses tl will usually be indicated on bronze bushings which are press the piston bosses. These are easily renewed and after rur reamer through them of the proper size no difficulty sh(experienced in replacing either the old or a new wrist pin (*ing upon the* condition of that member.

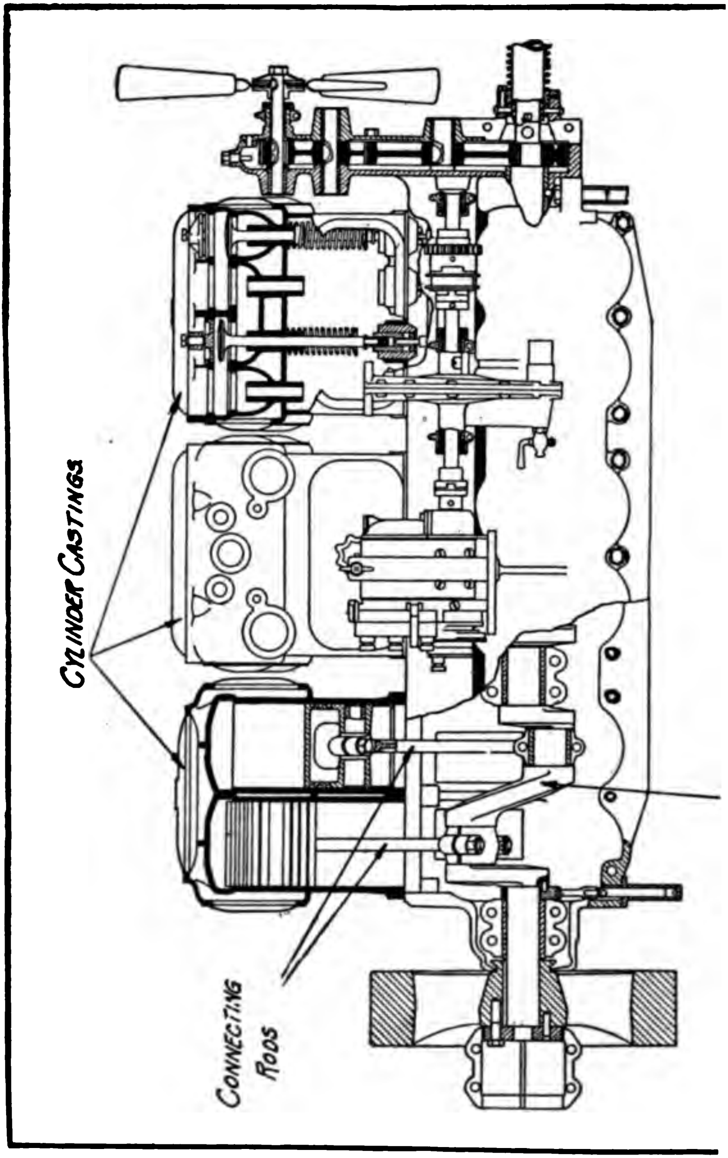
spection and Refitting of Engine Bearings.—While the en- is dismantled one has an excellent opportunity to examine arious bearing points in the engine crankcase to ascertain r looseness exists due to depreciation of the bearing surfaces. ll be evident from the views at Figs. 133 and 134, both main shaft bearings and the lower end of the connecting rods may sily examined for deterioration. With the rods in place as ı at Fig. 133, A, it is not difficult to feel the amount of lost n by grasping the connecting rod firmly with the hand and



134.—Top Half of Crankcase Showing Method of Crankshaft Retention by Three Main Bearing Caps.

ıg it up and down. The appearance of the engine base after onnecting rods and flywheel have been removed from the shaft is shown at Fig. 134, while the appearance of the upper ›n of the crankcase after the crankshaft is removed is clearly ı at Fig. 133, C.

fter the connecting rods have been removed and the flywheel off the crankshaft to permit of ready handling, any looseness e main bearing may be detected by lifting up on either the or rear end of the crankshaft and observing if there is any ıotion between *the shaft journal* and the main bearing caps.


CYLINDER CASTINGS
CONNECTING RODS

is not necessary to take an engine entirely apart to examine main bearings as in some forms these may be readily reached removing a large inspection plate either from the bottom or le of the engine crank case. In the Winton engine, which is own at Fig. 135, a distinctive method of crank case construction ised in which that member is divided vertically instead of horiitally as is the usual practice. One-half of the crank case may removed, this leaving the crankshaft and connecting rods suprted by the other half. It is not necessary to remove the cylincasting to gain access to the crank case interior. This type of struction is rare, however, and is found only on the engine de- outlined. The symptoms of worn main bearings are not hard identify. If an engine knocks when a vehicle is traveling over el roads regardless of speed or spark lever position and the uble is not due to carbon deposits in the combustion chamber may reasonably surmise that the main bearings have become e or that lost motion may exist at the connecting rod big ends, possibly at the wrist pins. The main journals of any well gned engine are usually proportioned with ample surface and not wear unduly unless lubrication has been neglected. The necting rod bearings wear quicker than the main bearings owto being subjected to a greater unit stress and it may be necesy to take these up several times in a season if the car is driven ny extent. Main bearings should run for ten thousand miles hout attention in a properly built engine that has always been oiled. Most connecting rod bearings will loosen up enough be taken up in five thousand miles.

Adjusting Main Bearings.—When the bearings are not worn gh to require refitting the lost motion can often be eliminated removing one or more of the thin shims or liners ordinarily d to separate the bearing caps from the seat. These are shown Fig. 131, A. Care must be taken that an even number of shims the same thickness are removed from each side of the journal. there is considerable lost motion after one or two shims have removed, it will be advisable to take out more shims and to pe the bearing to a fit before the bearing cap is tightened up. ay be necessary to clean *up the crankshaft* journals as these

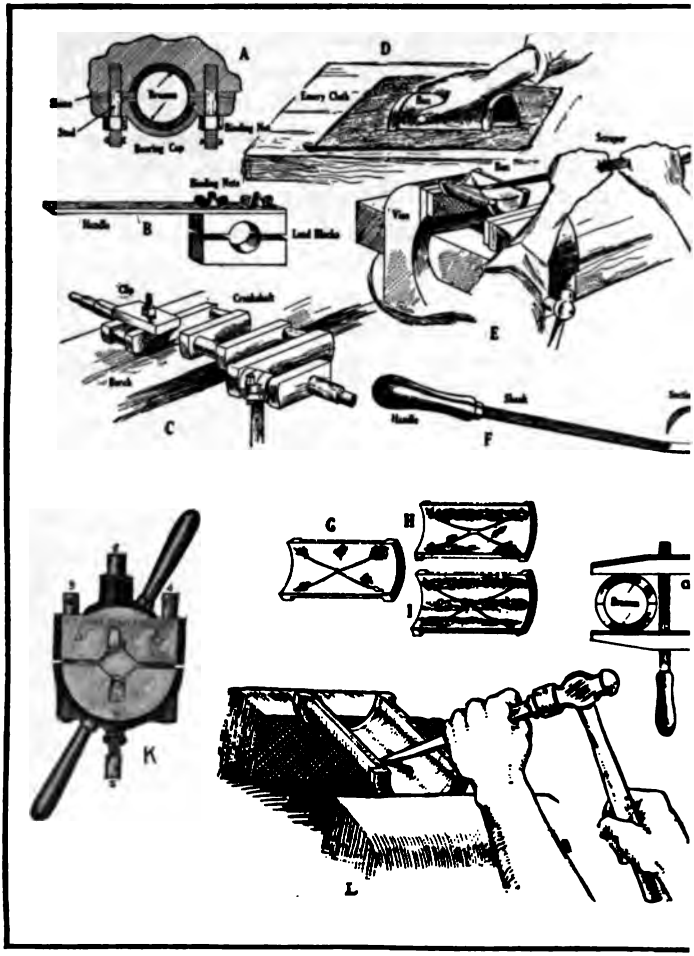


Fig. 136.—Processes and Tools Necessary for Bearing Restoı

may be scored due to not having received clean oil or ha
bearings seize upon them. It is not difficult to true up t
pins or main journals if the score marks are not deep. A
and emery cloth may be used, or a lapping tool such as
at Fig. 136, B. The latter is preferable because the file aı

cloth will only tend to smooth the surface while the lap will hav the effect of restoring the crank to proper contour.

A lapping tool may be easily made as shown at B, the block being of lead or hard wood. As the width of these are about hal that of the crank pin the tool may be worked from side to side a it is rotated. Another form of lapping tool and the method o using it which is practically the same as that we are now describin is shown at Fig. 139. An abrasive paste composed of fine emer powder and oil is placed between the blocks, and the blocks ar firmly clamped to the crank pin. While the approved method i to place the shaft between lathe centers as shown at Fig. 141, an revolve it slowly, guiding the lapping tool with the hand as th shaft revolves, the lathe is not always available. In that case th crankshaft may be clamped to the work bench as indicated at Fig 136, C, and the lapping tool turned by hand around the stationar crankshaft. It may not be necessary to remove the crankshaf from the engine base as a lapping tool may be used without diffi culty under the conditions shown at Fig. 139, C. As the lea blocks bend down, the wing nut should be tightened to insur that the abrasive will be held with some degree of pressure agains the shaft. A liberal supply of new abrading material is place between the lapping blocks and crankshaft from time to time an the old mixture cleaned off with gasoline. It is necessary to main tain a side to side movement of the lapping tool in order to hav the process affect the whole width of the crank pin equally. Th lapping is continued until a smooth surface is obtained.

If a crank pin is worn out of true to any extent the only metho of restoring it is to have it ground down to proper circular forn by a competent mechanic having the necessary machine tools t carry on the work accurately. In order to support a crankshaf in a lathe or grinding machine special forms of dogs may be use or special crankshaft supporting flanges may be made of cast iron An adjustable dog is shown at Fig. 140, A. This has a movabl center pad which can be moved up and down to provide for vary ing distances between the center line of the crank pin and th crankshaft when turning the crankpins. It is not difficult to sup port a crankshaft in a lathe when the work is to be done on th

main journal. This can be easily accomplished by the use of regular pattern lathe dogs and back rest as shown at Fig. 141, A. Machining the crank throws is more difficult as the crankshaft must be revolved eccentrically or on the crank pin centers instead of the main journal centers. The use of the special supporting flanges shown at Fig. 140, B, is clearly outlined in the lower portion of Fig. 141. It is necessary to use counterweights in order to balance the weight overhanging the center and to insure smooth rotation of the crank shaft. The journals may be machined either by putting on a very fine feed and using the conventional pattern of turning tools if the shaft is soft, or the journals may be ground if they are hard, if a grinding attachment is available.

The manner in which the adjustable dog or special crankshaft supporting flange works can be easily understood by referring to the drawing at Fig. 140. The distance between the center of the crank pin and crankshaft main journals depends entirely upon the stroke of the piston. This distance is invariably half of the stroke. For example, in an engine having a 5-inch stroke, the distance between the center lines would be 2½ inches. If suitable center holes are drilled in the face of the supporting flange at the proper distances from the crankshaft center it will be possible to line up the flange fittings very accurately to the crank pins and to support the shaft in such a way that the crank pins will revolve on the main center line passing through the lathe centers. This, of course, is essential in order to machine the shaft journal and crank pins true.

After the crankshaft is trued the next operation is to fit it to the main bearings or rather to scrape these members to fit the shaft journal. In order to bring the brasses closer together, it may be necessary to remove a little metal from the edges of the caps to compensate for the lost motion. A very simple way of doing this is shown at Fig. 136, D. A piece of medium emery cloth is rested on the surface plate and the box or brass is pushed back and forth over that member by hand, the amount of pressure and rapidity of movement being determined by the amount of metal it is necessary to remove. This is better than filing because the edges will be flat and there will be no tendency for the bearing

caps to rock when placed against the bearing seat. It is important to take enough off the edges of the boxes to insure that they will grip the crank tightly. The outer diameter must be checked with a pair of calipers during this operation to make sure that the surfaces remain parallel. Otherwise, the bearing brasses will only grip at one end and with such insufficient support they will quickly work loose, both in the bearing seat and bearing cap.

Scraping Brasses to Fit.—To insure that the bearing brasses will be a good fit on the trued up crank pins or crankshaft journals

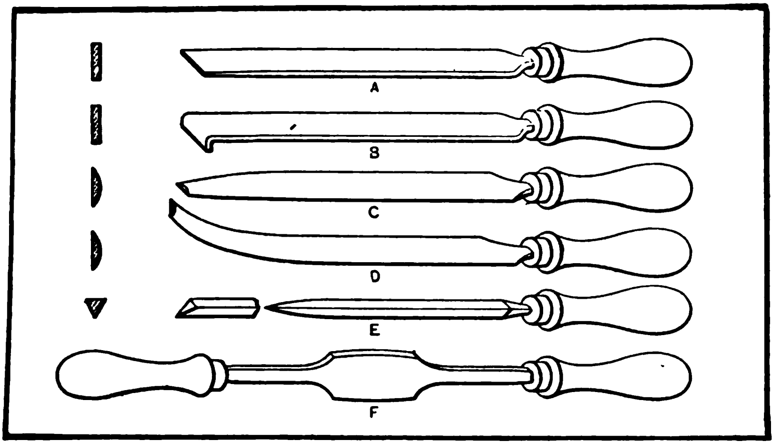


Fig. 137.—Conventional Forms of Bearing Scrapers.

they must be scraped to fit the various crankshaft journals. The process of scraping, while a tedious one, is not difficult, requiring only patience and some degree of care to do a good job. The surface of the crank pin is smeared with Prussian blue pigment which is spread evenly over the entire surface. The bearings are then clamped together in the usual manner with the proper bolts and the crankshaft revolved several times to indicate the high spots on the bearing cap. At the start of the process of scraping in, the bearing may seat only at a few points as shown at Fig. 136, G. Continued scraping will bring the bearing surface as indicated at H, which is a considerable *improvement*, while the process may b

considered complete when the brass indicates a bearing all over as at I. The high spots are indicated by blue, as where the shaft does not bear on the bearing there is no color. The high spots are removed by means of a scraping tool of the form shown at Fig. 136, F, which is easily made from a worn out file. These are forged to shape and ground hollow as indicated in the section and are kept properly sharpened by frequent rubbing on an ordinary oil stone. To scrape properly, the edge of the scraper must be very keen.

Other forms of scrapers used in machining operations are shown at Fig. 137. The flat scraper A, is used for plain surfaces For ordinary use the blade is about $\frac{3}{16}$-inch thick, about 1-inch wide and is drawn at the point to a thickness of about $\frac{1}{16}$-inch. The cutting edge is made as hard as possible. The hook scraper B, is also used on flat surfaces. The straight and curved half round scrapers shown at C and D, are used for bearings. The three cornered scraper outlined at E, is also used on curved surfaces and is of value in rounding off the sharp corners. For scraping very large engine bearings, such as used for stationary work the two handle scraper shown at F, is valuable, though there are not many applications in automobile work where this type of tool is necessary. The straight or curved half round type works well on soft-bearing metals, such as babbit, or white brass, but on yellow brass or bronze it cuts very slowly, and as soon as the edge becomes dull considerable pressure is needed to remove any metal this calling for frequent sharpening.

When correcting errors on flat or curved surfaces by hand scraping, it is desirable, of course, to obtain an evenly spotted bearing with as little scraping as possible. When the part to be scraped is first applied to the surface-plate, or to a journal in the case of a bearing, three or four "high" spots may be indicated by the marking material. The time required to reduce these high spots and obtain a bearing that is distributed over the entire surface depends largely upon the way the scraping is started. If the first bearing marks indicate a decided rise in the surface, much time can be saved by scraping larger areas than are covered by the bearing marks; this is especially true of large shaft and engine

bearings, etc. An experienced workman will not only remove t heavy marks, but also reduce a larger area; then, when the beari is tested again, the marks will generally be distributed somewh If the heavy marks which usually appear at first are simply moved by light scraping, these "point bearings" are gradual enlarged, but a much longer time will be required to distribu them.

The number of times the bearing must be applied to the journ for testing is important, especially when the box or bearing large and not easily handled. The time required to distribute t bearing marks evenly depends largely upon one's judgment "reading" these marks. In the early stages of the scraping oper tion, the marks should be used partly as a guide for showing t high areas, and instead of merely scraping the marked spot t surface surrounding it should also be reduced, unless it is evide that the unevenness is local. The idea should be to obtain fi a few large but generally distributed marks; then an evenly a finely spotted surface can be produced quite easily.

In fitting brasses when these are of the removable type, t methods may be used. The upper half of the engine base may inverted on a suitable bench or stand and the boxes fitted by pl ing the crankshaft in position, clamping down one bearing cap a time and fitting each bearing in succession until they bed equall From that time on the bearings should be fitted at the same ti so the shaft will be parallel with the bottom of the cylinders. Co siderable time and handling of the heavy crankshaft may be sav if a preliminary fitting of the bearing brasses is made by clampi them together with a carpenter's wood clamp as shown at Fi 136, J, and leaving the crankshaft attached to the bench as sho at C. The brasses are revolved around the crankshaft journal a are scraped to fit wherever high spots are indicated until th begin to seat fairly. When the brasses assume a finished appe ance the final scraping should be carried on with all bearings place and revolving the crankshaft to determine the area of t seating. When the brasses are properly fitted they will not on show a full bearing surface but the shaft will not turn undu hard if revolved with the same amount of leverage as afforded

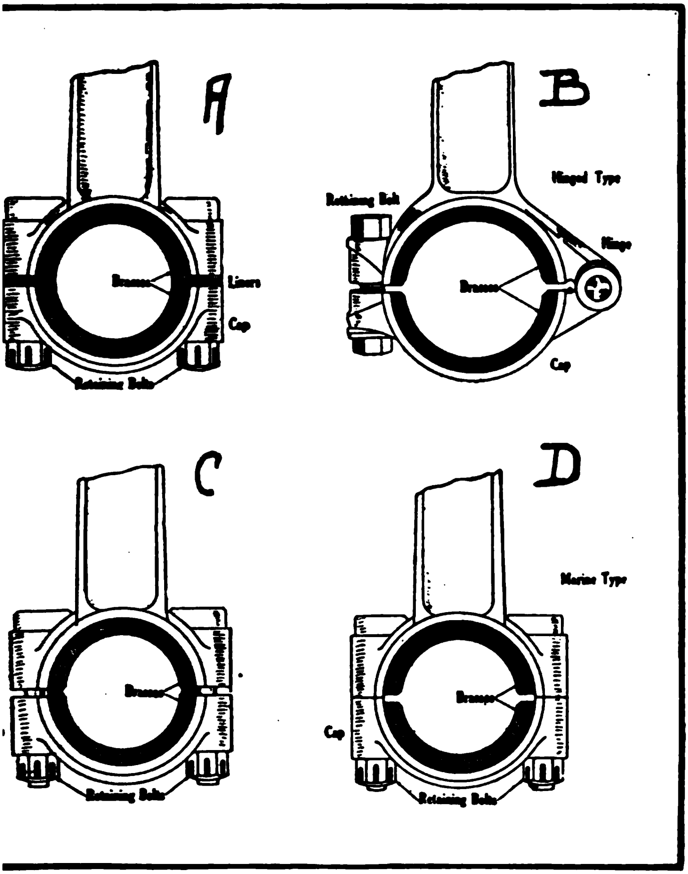
the flywheel rim or starting crank, all bearing caps being properly bedded down and lubricated.

Bearings of white metal or babbitt can be fitted tighter than those of bronze, and care must be observed in supplying lubricant as considerably more than the usual amount is needed until the bearings are run in by several hundred miles of road work. Before the scraping process is started it is well to chisel an oil groove in the bearing as shown at Fig. 136, L. Grooves are very helpful in insuring uniform distribution of oil over the entire width of bearing and at the same time act as reservoirs to retain a supply of oil. The tool used is a round nosed chisel, the effort being made to cut the grooves of uniform depth and having smooth sides. Care should be taken not to cut the grooves too deeply as this will seriously reduce the strength of the bearing bushing. The shape of the groove ordinarily provided is clearly shown at Fig. 136, G, and it will be observed that the grooves do not extend clear to the edge of the bearing, but stop about a quarter of an inch from that point. The hole through which the oil is supplied to the bearing is usually drilled in such a way that it will communicate with the groove.

The tool shown at Fig. 136, K, is of recent development and is known as a "crankshaft equalizer." This is a hand operated turning tool carrying cutters which are intended to smooth down scored crank pins without using a lathe. The feed may be adjusted by suitable screws and the device may be fitted to crank pins and shaft journals of different diameters by other adjusting screws. This device is not hard to operate, being merely clamped around the crankshaft in the same manner as the lapping tool previously described, and after it has been properly adjusted it is turned around by the levers provided for the purpose, the continuous rotary motion removing the metal just as a lathe tool would.

Remetalling and Fitting Connecting Rods.—Fitting and adjusting rod bearings, especially those at the crank pin end, is one of the operations that must be performed several times a season if a car is used to any extent. There are two forms of connecting rods in general use, known respectively as the marine type, shown

38, A, and the hinged form depicted at Fig. 138, B. The
›e is the simplest, but one clamp bolt being used tc keep
together as the cap is hinged to the rod end on one side,



138.—Outlining Common Types of Connecting Rod Big Ends.

nitting the lower portion to swing down and the crank
ass out from between the halves when the retaining bolt
ed. In the marine type, which is the most common, one or
are employed at each side *and the* cap must be removed

entirely before the bearing can be taken off of the crai The tightness of the brasses around the crank pin can n(determined solely by the adjustment of the bolts, as whi important that these should be drawn up as tightly as]

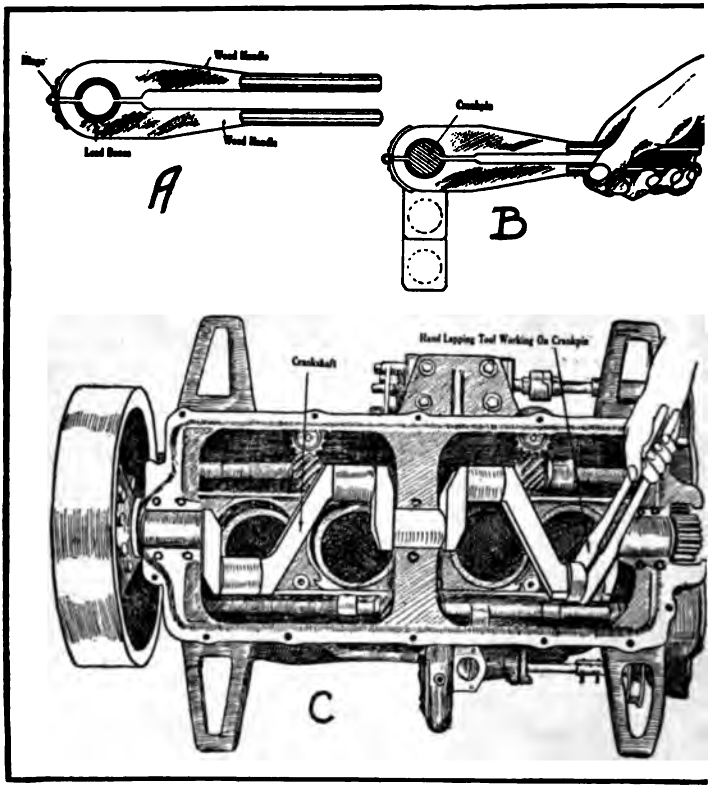
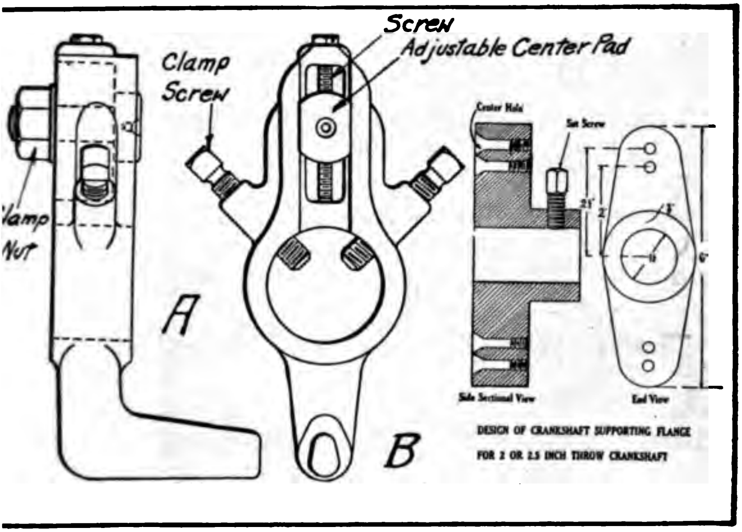


Fig. 139.—Simple Lapping Tool for Crank Pin and Method of

the bearing should fit the shaft without undue binding, e the brasses must be scraped to insure a proper fit. As is t the main bearings, the marine form of connecting rod has a n of liners or shims interposed between the top and lower p of the rod end and these may be reduced in number when *sary tp* bring the brasses closer together.

:n fitting new brasses there are two conditions to be avoided, e being outlined at Fig. 138, C and D. In the case shown ! the light edges of the bushings are in contact, but the connect- rod and its cap do not meet. When the retaining nuts are .tened the entire strain is taken on the comparatively small ı of the edges of the bushings which are not strong enough to ıstand the strains existing and which flatten out quickly, per-



:. 140.—Adjustable Center Lathe Dog and Crankshaft Supporting Flange for Use in Turning Crank Pins on Lathes.

:ing the bearing to run loose. In the example outlined at D edges of the brasses do not touch when the connecting rod cap rawn in place. This is not good practice, because the brasses ı become loose in their retaining member. In the case outlined necessary to file off the faces of the rod and cap until these t, and to insure contact of the edges of the brasses as well. :vent of the brasses coming together before the cap and rod e contact, as shown at C, the bearing halves should be reduced he edges until both the caps and brasses meet against the aces of *the liners as shown at A.*

Before assembling on the shaft, it is necessary to fit the b
by scraping, the same instructions given for restoring the c
of the main bearings applying just as well in this case.
apparent that if the crank pins are not round no amo
scraping will insure a true bearing. A point to observe is t
sure that the heads of the bolts are imbedded solidly in
proper position and that they are not raised by any bu

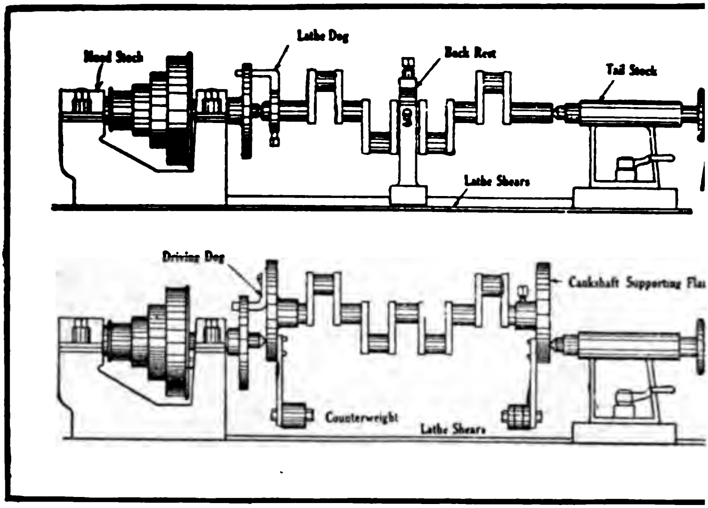


Fig. 141.—At A, Method of Supporting and Driving Cranksha Turning Main Bearings. At B, Showing Use of Crankshaft Su ing Flanges when Machining Crank Pins.

particles of dirt under the head which will flatten out af
engine has been run for a time and allow the bolts to sl
Similarly, care should be taken that there is no foreign mat
der the brasses and the box in which they seat. To guard
this the bolts should be struck with a hammer several time
they are tightened up, and the connecting rod can be hit
several times under the cap with a wooden mallet or lead h
It is important to pin the brasses in place to prevent mo
as lubrication may be interfered with if the bushing turns

eaks the correct register between the oil hole in the cap asses.

: should be taken in screwing on the retaining nuts to that they will remain in place and not slack off. Spring should not be used on either connecting rod ends or main bolts, because these sometimes snap in two pieces and e nut slack. The best method of locking is to use well-plit pins and castellated nuts. In a number of the cheaper bearing metal is cast in place in the connecting rod lower in main bearings, and is not in the form of removable bushings as are used on the more expensive cars. The an who is called upon to replace the bearing metal will following instructions regarding remetalling bearings of The method described was used by the writer while in of a large shop where much work of this kind was done le the instructions given apply specifically to lining the s of connecting rods, the same process may be used suc- on any other bearings where the mandrel and collars sed, the dimensions being changed to suit the requirements vorker.

ie case mentioned the journals of the crankshaft were two n diameter and the big ends of the connecting rods were o much to allow of adjusting. A piece of pipe about 9 ong was procured and turned down in a lathe until it was under 2 inches in diameter, which made a hollow mandrel A piece of steel tubing could have been used to as good ge had any been available. As the outside of the bearing re machined true a couple of set collars were bored out good fit on the mandrel, and while still in the lathe they cessed out to just fit over the outside of the big ends, as n sketch Fig. 4. One of these collars was placed on the mandrel A, after which the mandrel was pushed through end, and the other collar was put on the other side, insur- the mandrel was as near center as possible for it to be. assemblage is then supported on a couple of V-blocks, which ported on a lathe bed, the ends of the mandrel lying within while the connecting rod hangs between the ways. A piece

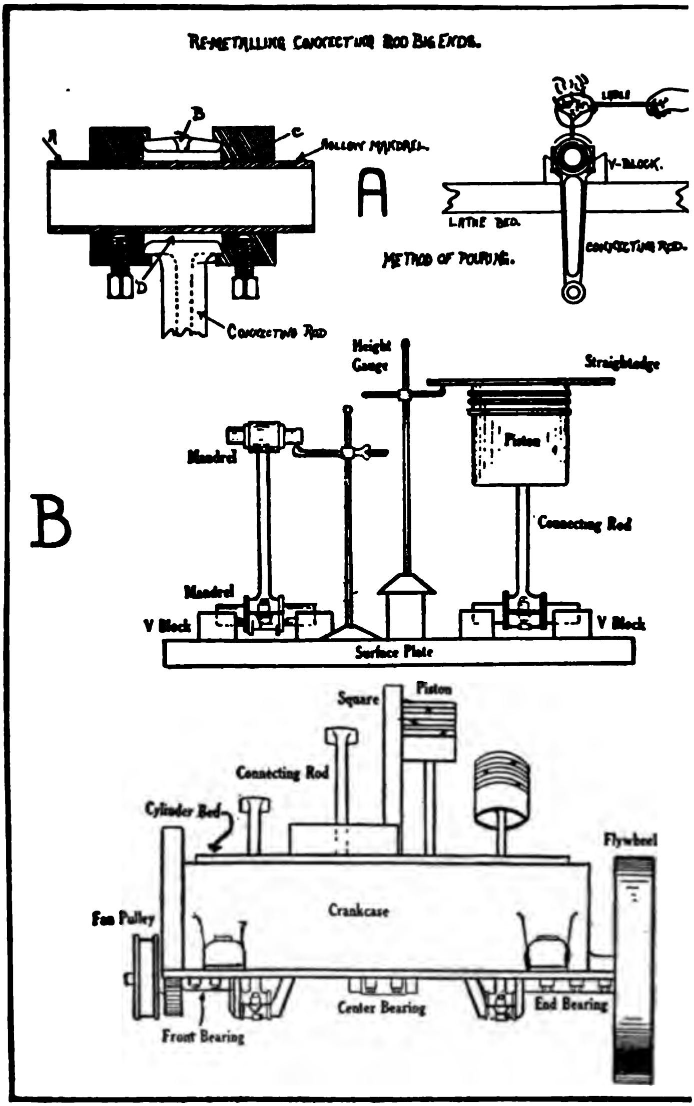


Fig. 142.—Showing Simple Method of Remetalling Connecting R ings at A, and Ways of Measuring Parallelism of Upper an *Connecting* Rod Bearings at B and C.

solid round iron or steel which will go inside of the hollow andrel should be made red hot while the anti-friction metal is eing melted and is pushed inside the mandrel to heat it. In a inute or two the metal may be poured in through B to fill D, nd as the metal and the big end caps are well heated the molten netal will flow to every point. The heating of the mandrel can e just as well accomplished by directing the flame from a blow orch or Bunsen burner into the opening. After the metal is poured and has set the whole may be easily cooled by running water through the mandrel or by directing a blast of air against the big end, as desired.

Before the cap is assembled with the connecting rod several shims or liners of sheet brass or copper should be placed between them so that adjustment for wear of the new bearing can be compensated for by the removal of a liner. As is evident, the thinner the liner and the greater the number used, the more sensitive the character of adjustment possible.

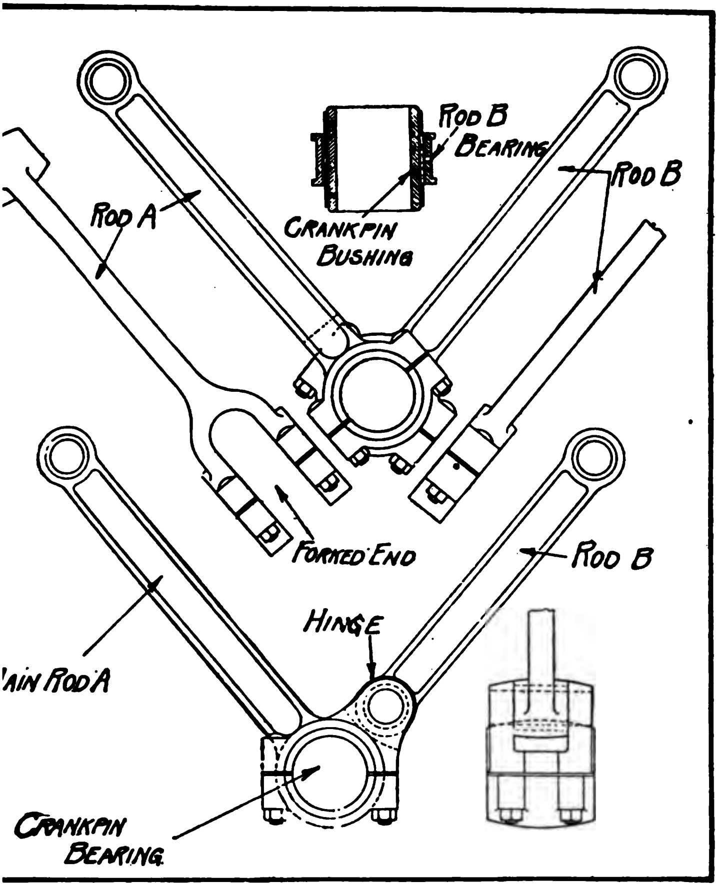
The use of a hollow mandrel is to be preferred to a solid one because of the ease with which it can be heated and cooled. Vents should be made for the heated gases by grooving the face of each of the collars nearest the big end and on the same side as the hole through which the metal is poured. If provision is not made for "venting" the molten metal will not run uniformly and will become honeycombed. After cooling the bearing is either bored out in a lathe to the size of the journal or scraped to a fit by hand. The method of pouring the molten metal is clearly shown while the sectional view makes the construction and application of the mandrel clear. The same method may be used to rebabbitt main boxes except that a pair of collars will be needed for each bearing and a long mandrel used.

Testing Bearing Parallelism.—It is not possible to give other than general directions regarding the proper degree of tightening for a connecting rod bearing, but as a guide to correct adjustment it may be said that if the connecting rod cap is tightened sufficiently so the connecting rod will just about fall over from a vertical position due to the piston weight when the bolts are fully tightened up, the adjustment will be nearly correct. As previ

ously stated, babbitt or white metal bearings can be set up ı tightly than bronze, as the metal is softer and any high spots soon be leveled down with the running of the engine. It is in tant that care be taken to preserve parallelism of the wrist and crankshafts while scraping in bearings. This can be d mined in two ways. That shown at Fig. 142, B, is used ı the parts are not in the engine assembly and when the conne rod bearing is being fitted to a mandrel or arbor the same as the crank pin. The arbor, which is finished very smooth ar uniform diameter, is placed is two V blocks, which in turn supported by a level surface plate. An adjustable height g may be tried, first at one side of the wrist pin which is place the upper end of the connecting rod, then at the other, and variation will be easily determined by the degree of tilting o rod. This test may be made with the wrist pin alone, or i piston is in place, a straight edge or spirit level may be emplo The spirit level will readily show any inclination while the stra edge is used in connection with the height gauge as indicated

When the connecting rods are being fitted with the cranks in place in crankcase, and that member secured in the fram steel square may be used as it is reasonable to assume that wrist pin, and consequently the piston it carries, should ob a true relation with the top of the engine base. If the piston is at right angles with the top of the engine base it is reason to assume that the wrist pin and crank pin are parallel. If piston is canted to one side or the other, it will indicate that brasses have been scraped tapering, which would mean consi able heating and undue friction if the piston is installed in cylinder on account of the pressure against one portion of cylinder wall. The height gauge method shown above may used instead of the steel square, if designed, because the top of crank case is planed or milled true and should be parallel the center line of the crankshaft.

On the new eight-cylinder V types of engines which are f on several models of 1915 cars the connecting rod design is ferent from that ordinarily used, as it is sometimes necessar *have two rods* working from the same crank pin. The constru



143.—Showing Construction of Connecting Rod Needed with Eight ylinder V Engine Unless Carried Side by Side on Crankpins.

s very closely that used in motorcycle engines of the two-er V form. Two methods of connecting rod arrangement own at Fig. 143. In the example at the top of the illus-ı, connecting rod A has a forked end which encircles the crank pin bushing. These ends are of the usual marine straddling the *big end of rod B,* which is free to oscil-

late on the crank pin bushing. Care must be taken to fit r A in such a manner that it will be clamped tightly around the e of the main crank pin bushing so that member will move unison with rod A. The method outlined in the lower view u a master or main rod A of the conventional pattern, excepti that a slotted boss is forged on one side of the connecting r to take the lower end of rod B, which hinges on a suitable be ing pin. The crank pin bearing works in connection with ma rod A just as in a four-cylinder engine, and the point to be watch

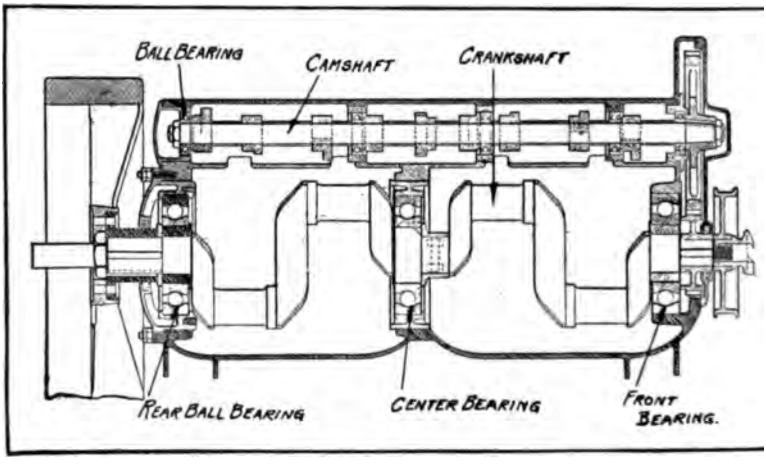
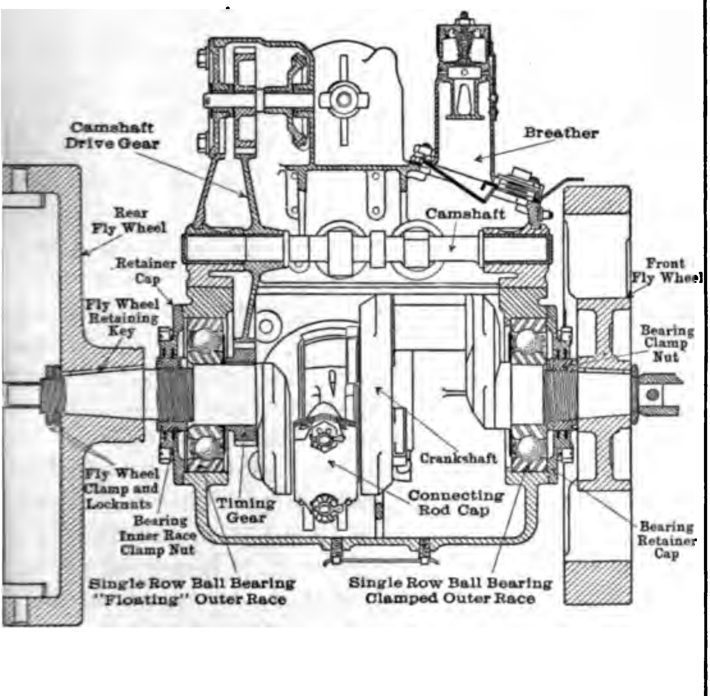


Fig. 144.—Showing Practical Application of Ball Bearings for Crankshaf and Camshaft Support.

for wear is at the hinge where rod B fastens to the main r The same method of fitting brasses that has been previously (scribed in connection with the conventional forms of bearings app just as well to the special type, though somewhat greater care w be necessary in fitting the yoke or forked end rod constructi than is required with the simpler bearing subject to wear only its inner periphery.

Ball Bearing Crankshaft.—A number of automobile engir utilize ball bearings for supporting the crankshaft as outlined *Figs. 144 and 145.* While these bearings are usually selected

margin of strength is present and the bearings have much resisting power than is needed, after the engine has been · a time these may have loosened, and as a result are noisy ›n. Ball bearings cannot be refitted as plain bearings can, ıen worn it is necessary to replace them with entirely new rs. This work is not difficult as these bearings are machined :curately, and usually there is no depreciation at either the ıaft or the bearing housing owing to all of the wear having d in the bearing itself. The process of replacement, there-



15.—Section of Autocar Motor Crankcase *Showing* Ball Bearing *Crankshaft.*

fore, is a simple one, consisting mainly of forcing off the wor members and forcing on new ones in their place. The method o bearing retention outlined is a common one. One of the bearing in this case the rear one, has the outer race securely held agains end movement in the retaining housings, while the inner race i also tightly clamped around the crankshaft journal by means o a spacing washer and flange member tightly pressed against th bearing inner race by a suitable clamping nut. The front mai bearing has only the inner race clamped. The crankshaft timin gear serves to transmit the end pressure of the nut on the fron end of the shaft, which has the starting dogs or ratchet forme at one end. The idea of this is so that the pressure applied to star the engine with the hand crank will result in keeping the clampin nut tight due to the leverage of the crank. The center mai bearing has a floating outer race just as the front bearing ha This means that neither of these bearings will be called upon t resist end thrust and insures that they will be subjected to onl radial loads. The inner race of the center main bearing is clampe against the suitable shoulder by a slit bushing which encircles th crankshaft and which takes up the space between the bearing inne race and the crankshaft web. Most engines using ball bearing have crankshafts of the two bearing form, which means that th center bearing is eliminated and only the end bearings used. Thi construction has been made possible by the almost universal pra tice of casting four cylinders "en bloc," but the bearings are hel in the same manner. The instructions given for the care an installation of ball bearings in the chapter on running gear con ponents applies just as well to those used for crankshaft suppor

Camshafts and Timing Gears.—Knocking sounds are also ev dent if the camshaft is loose in its bearings, and also if the can or timing gears are loose on the shaft. The camshaft is usuall supported by solid bearings of the removable bushing type, havin no compensation for depreciation. If these bearings wear the onl remedy is replacement with new ones. In the older makes of ca it was general practice to machine the cams separately and t secure these to the camshaft by means of taper pins or key These members sometimes loosened and caused noise. In event

ie cams being loose, care should be taken to use new keys or iper pins, as the case may be. If the fastening used was a pin, he hole through the camshaft will invariably be slightly oval from rear. In order to insure a tight job, the holes in cam and shaft nust be reamed with the next larger size of standard taper reamer ind a larger pin driven in. Another point to watch is the method of retaining the camshaft gear in place. On some engines the gear is fastened to a flange on the camshaft by retaining screws. These are not apt to become loose, but where reliance is placed on a key the camshaft gear may often be loose on its supporting member. The only remedy is to enlarge the key slot in both gear and shaft and to fit a larger retaining key.

If the camshaft is sprung or twisted it will alter the valve timing to such an extent that the smoothness of operation of the engine will be materially affected. If this condition is suspected the crankshaft may be swung on lathe centers and turned to see if it runs out and can be straightened in any of the usual form of shaft-straightening machines. The shaft may be twisted without being sprung. This can only be determined by supporting one end of the shaft in an index head and the other end on a milling machine center. The cams are then checked to see that they are separated by the proper degree of angularity. This process is one that requires a thorough knowledge of the valve timing of the engine in question, and is best done at the factory where the engine was made. The timing gears should also be examined to see if the teeth are worn enough so that considerable back lash or lost motion exists between them. This is especially important where worm or spiral gears are used. A worn timing gear not only produces noise, but it will cause the time of opening and closing of the engine valves to vary materially.

Valve Timing Methods.—Among the important factors making for efficient operation of the gas or gasoline engine, especially of the multiple cylinder type used for automobile propulsion, there is none of more importance than proper valve timing. In a four-cylinder four-cycle motor there are eight of these members, two o each cylinder, the function of the inlet valves being to permit he cylinders to fill with gas while the exhaust valves open to

clear the cylinders of the products of combustion. The inlet v usually opens when the piston is at approximately the top of stroke in the cylinder, or during that portion of the engine c where the piston is starting to go down to draw in a charge gas. This valve is opened a period equal to the downstroke of piston, and sometimes more, but is closed during the succeed compression, explosion and scavenging strokes. The operation the exhaust valve is very much the same as the inlet, except t it is opened for a longer period, starting to open before the pis has completed the downward stroke produced by the explo and is sometimes opened slightly after the end of the return scavenging stroke.

It is important that the valves open and close according to timing instructions issued by the maker of the motor if maxim efficiency is to be obtained from the power plant. As the val are operated by cams, which in turn are mounted on and dri by a shaft turning at half the crankshaft speed, the periphery the flywheel rim may be utilized to indicate the valve timing the motor by means of suitable marks which will register wit trammel or indicator point usually fixed back of the rear cylin with the pointer exactly on the longitudinal center line of engine. At first glance the marks on the flywheel may be c fusing, but they are easily understood if one considers the b operation of a four-cylinder four-cycle motor and remembers an explosion must take place in some cylinder for every pe indicated by one-half revolution of the flywheel. As the va are usually timed to remain open a definite number of deg measured by the crankshaft rotation, the timing may be acc plished in two ways, that previously described by following wheel markings or by noting the travel of the piston in the cy der with some form of depth gauge. Some manufacturers a timing the motor by following the piston travel directly. O make provision for this timing by marking the motor flywh

In marking a flywheel rim, one only needs to remember every circle may be divided into 360 or more parts, though usually used because it indicates in degrees, whereas the sm *subdivisions*, which would be in minutes and seconds, a

eded. If the flywheel is not already marked, as might be the se if the maker followed the system of timing by piston movent directly, it is not difficult for any repairman to mark the ywheel rim if he knows the points of openings and closing of the lve as expressed in degrees of crankshaft travel. The first marks make are the points at which two of the pistons are at the top f the stroke and two at the bottom. This is usually done by nsidering the cylinder nearest the radiator, or at the front of e motor No. 1 and the others in order 2, 3 and 4. The first ark made on the flywheel rim is when the piston in cylinder o. 1 is brought to the end of its stroke or toward the closed end f the cylinder. A point is prick punched on the flywheel to rrespond with the pointer of the trammel or indicator. This called "top center" cylinders 1 and 4. This may be abbreated as "T.C.1-4." which is very easily indicated on the iron n of the flywheel with ordinary steel letter stamps. The flywheel then turned over a half revolution until the piston in Number 1 linder is at the bottom of its stroke. Another point is then incated on the flywheel and this is marked "B.C.1-4" which is abbreviation for "bottom center," cylinders 1 and 4. If, for ample the inlet valve in number 1 cylinder opens fifteen dees after top center a distance is measured off on the flywheel a equal to a crank shaft travel of 15 degrees. A line is then ibed across the face of the flywheel and this is marked "inlet ens" 1 and 4. If the inlet valve closed 20 degrees after bottom nter the flywheel is rotated half a turn until the bottom center e registers with the trammel. A suitable distance is then meased off on the flywheel face from that point that would be equal a travel of 20 degrees on a circle represented by the circumrence of the flywheel.

The rule for determining the amount of space to allow for a gree is not a difficult one to apply in practice. It is merely essary to multiply the diameter of the flywheel in inches by onstant value, 3.1416, which remains the same regardless of meter of the flywheel, to obtain the circumference of the flyel in inches. This product is divided by 360, which gives the unt of space to measure *off on the flywheel* rim for each de-

gree. While the figuring is not difficult, the result may be quickly arrived at by reference to the accompanying table of a and corresponding arcs which has been compiled by A. C. W bury and printed in the Horseless Age. A conversion tab also appended which will be of value inasmuch as it permit conversion of hundredths of an inch to sixty-fourths of an i which subdivision is more apt to be found on standard fle scales used by American machinists.

After having marked the flywheel for the inlet valve, the operation is to indicate the points of opening and closing for exhaust valve of No. 1 cylinder. As a rule, the exhaust v opens about 45 degrees ahead of the bottom center position of piston when that member is impelled downward by the force of explosion. Following the closing of the inlet valve, nearly strokes of the piston takes place before the exhaust opens, being the stroke corresponding to the compression of the while the other corresponds to the downward travel of the pi due to explosion pressure. The exhaust valve usually clos few degrees before the inlet opens, though on some engines exhaust may not be fully closed before the intake starts to c

A cross section view of a four-cylinder engine with the v located in the combustion heads is shown at Fig. 146, which indicates the method employed of marking the flywheel and the relation of the various strokes for the two most commonly firing orders employed with four-cylinder motors. The explo do not occur in each cylinder in the same sequence as the cylin are numbered. An explosion in cylinder No. 1 is followed by in No. 2, then by one in No. 4, and lastly by one in No. 3, acc ing to one method. In the other the firing order is 1—3— In other words, the explosions must follow each other in cylin 1 and 2 or in cylinders 3 and 4, because in these one piston i while the other is down.

Considering the firing order first named, if an explosio taking place in cylinder No. 1 driving the piston downward piston in cylinder No. 2 is compressing a charge as it is mo upward, that in No. 3, which is moving in the same directio the piston in No. 2, is expelling the burnt gas, and the pist

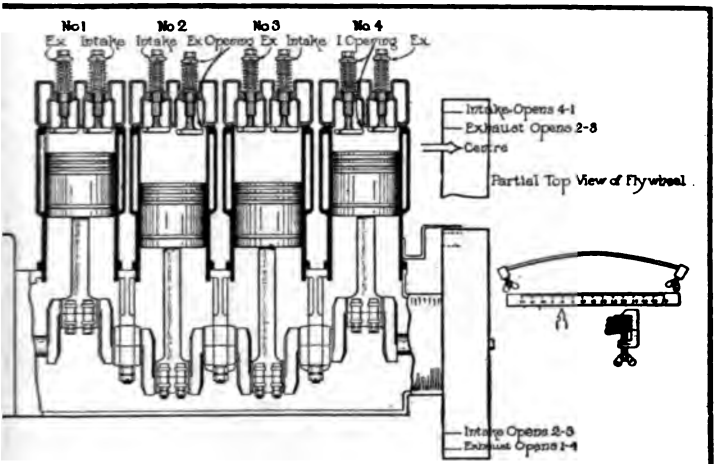
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.00	1.20	1.40	1.61	1.81	2.01	4.02	6.02	8.03	10.03
¼	73.042	.20	.41	.61	.81	1.01	1.22	1.42	1.62	1.82	2.03	4.06	6.09	8.13	10.13
½	73.827	.20	.41	.61	.82	1.02	1.23	1.43	1.64	1.84	2.05	4.10	6.15	8.21	10.23
¾	74.613	.21	.41	.62	.83	1.04	1.24	1.45	1.66	1.86	2.07	4.15	6.22	8.30	10.35
24	75.398	.21	.42	.63	.84	1.05	1.26	1.46	1.67	1.88	2.09	4.19	6.28	8.38	10.45

CONVERSION TABLE, HUNDREDTHS OF AN INCH TO SIXTY-FOURTHS

.01, .02.. 1/64	.14...... 9/64	.26, .27..17/64	.39......25/64	.51, .52..33/64	.64......41/64	.76, .77..49/64	.89......57/64
.03...... 1/32	.15, .16.. 5/32	.28...... 9/32	.40, .41..13/32	.53......17/32	.65, .66..21/32	.78......25/32	.90, .91..29/32
.04, .05.. 3/64	.17......11/64	.29, .30..19/64	.42......27/64	.54, .55..35/64	.67......43/64	.79, .80..51/64	.92......59/64
.06, .07.. 1/16	.18, .19.. 3/16	.31, .32.. 5/16	.43, .44.. 7/16	.56, .57.. 9/16	.68, .69..11/16	.81, .82..13/16	.93, .94..15/16
.08...... 5/64	.20, .21..13/64	.33......21/64	.45, .46..29/64	.58......37/64	.70, .71..45/64	.83......53/64	.95, .96..61/64
.09, .10.. 3/32	.22...... 7/32	.34, .35..11/32	.47......15/32	.59, .60..19/32	.72......23/32	.84, .85..27/32	.97......31/32
.11...... 7/64	.23, .24..15/64	.36......23/64	.48, .49..31/64	.61......39/64	.73, .74..47/64	.86......55/64	.98, .99..63/64
.12, .13.. 1/8	.25...... 1/4	.37, .38.. 3/8	.50...... 1/2	.62, .63.. 5/8	.75...... 3/4	.87, .88.. 7/8	1.00...... 1

Table of Angles and Corresponding Arcs for Diameters from 12 to 24 inches, Useful in Marking Fly-wheels in Valve Timing. Note Conversion Table for Changing Hundredths of an Inch to Sixty-fourths.

, which is moving down or in the same direction as piston , is drawing in a charge of gas. At the completion of the ion stroke in cylinder No. 1 the positions of the pistons is verse to that shown in the illustration, i.e., pistons in No. 1 Io. 4 are at the open end of the cylinder, whereas those in and No. 3 are at the top or closed end.



How Valves Are Timed and Tappets Adjusted by Utilizing the Markings on the Flywheel.

FIRING ORDER 1-2-4-3.

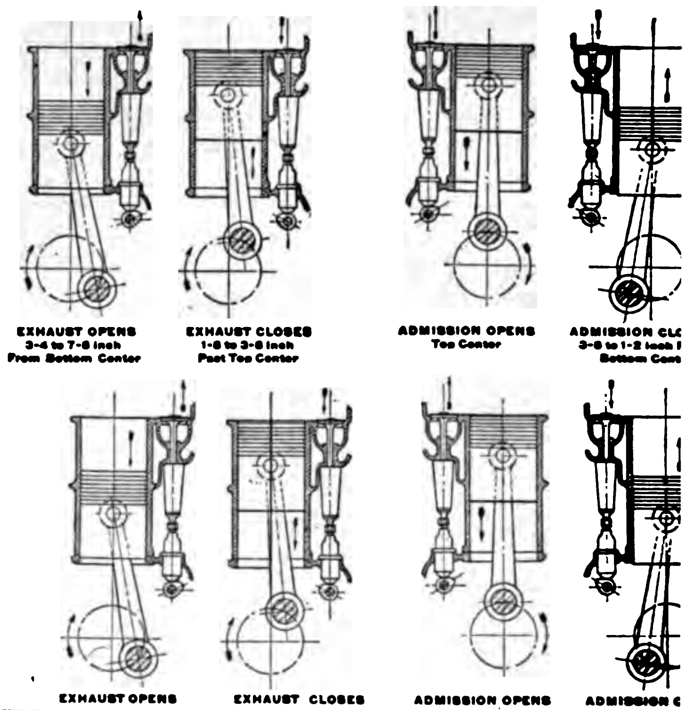
nder 1	Cylinder 2	Cylinder 3	Cylinder 4
ing	Compression	Exhaust	Suction
haust	Firing	Suction	Compression
ction	Exhaust	Compression	Firing
mpression	Suction	Firing	Exhaust

FIRING ORDER 1-3-4-2.

Cylinder 1	Cylinder 2	Cylinder 3	Cylinder 4
1—Firing	Exhaust	Compression	Suction
2—Exhaust	Suction	Firing	Compression
3—Suction	Compression	Exhaust	Firing
4—Compression	Firing	Suction	Exhaust

146.—Explaining Method of Timing Valves and Marking Flywheel of Four Cylinder Motor.

hen piston No. 1 starts to go up again it will be forcing out rnt gas due to the previous explosion. That in No. 2, which ached the top end of the stroke just after compressing the , is subjected to the explosion; that in No. 3, which moves same direction as piston No. 2, and which has just cleared e burnt gas, is drawing in a fresh charge, while piston No. 4 ving toward the top of the cylinder, compressing the gas d during the preceding downward *stroke*. The remainder



	EXHAUST OPENS	EXHAUST CLOSES	ADMISSION OPENS	ADMISSION C
1911 "48"	11-16" Before bottom center	⅛" Past top center	Top center	⅝" Past bottom
1913 "48"	1" Before bottom center	¼" Past top center	Top center	⅝" Past bottom
1913 "38"	⅝" Before bottom center	⅛" Past top center	Top center	⅝" Past bottom

Fig. 147.—Instructions Given by the Locomobile Company for Timing of its Various Early Models.

of the operations may be readily followed by the reader by ing the illustrations and the explanatory context.

At Fig. 147 the system of valve timing employed on models of the Locomobile cars is clearly outlined. At the t points of opening and closing of the valves in the Loco Model L, as measured by piston travel, are depicted, whi *bottom series* shows the timing of the models R and M for a

of years. It will be apparent that it would not be difficult t measure the piston travel by inserting a suitable depth gaug through a petcock at the top of the cylinder, so a rod or wi could be employed to follow the piston movement.

At Fig. 148 the valve timing of the 1915 Overland motor outlined, this showing the method of indicating the points on th flywheel rim, and also the amount of travel of the crankshaft t conform to the number of degrees opening and closing of th valve. The marks on the flywheel and their meaning follows:

1-4 Up means: cylinders 1 and 4 are in their uppermost position.
2-3 Up means: cylinders 2 and 3 are in their uppermost position.
1-4 I-O means: inlet valve of cylinder 1 or 4 opens.
1-4 I-C means: inlet valve of cylinder 1 or 4 closes.
1-4 E-O means: exhaust valve of cylinder 1 or 4 opens.
1-4 E-C means: exhaust valve of cylinder 1 or 4 closes.
2-3 I-O means: inlet valve of cylinder 2 or 3 opens.
2-3 I-C means: inlet valve of cylinder 2 or 3 closes.
2-3 E-O means: exhaust valve of cylinder 2 or 3 opens.
2-3 E-C means: exhaust valve of cylinder 2 or 3 closes.

To determine when the setting of the valves is correct procee as follows, beginning with cylinder No. 1: First open the primin cocks over all exhaust valves to relieve the compression and t make flywheel rotation easier. Second, turn the flywheel to th left until the mark 1-4 Up is in line with the punched guide mar on No. 4 cylinder. Pistons No. 1 and No. 4 are now at the highest points, or on upper dead center. About 1¼ inch to th right of the mark one will notice another indication, 1-4 I (Turn the flywheel to the left until this mark is lined up with th punch mark on cylinder. At this point the inlet valve of eith cylinder No. 1 or cylinder No. 4 should begin to lift. If the li should occur in cylinder No. 4, turn the flywheel one comple revolution until the marks 1-4 I O again appear on top and i line with the guide marks. Now feel of the inlet valve lift plung of cylinder No. 1, which should be in contact with the inlet valv stem, and further rotation of the flywheel to the left should begi to produce a lift of the inlet valve, which may be observed b watching the upward *movement of the* valve stem. Third, to d

termine the closing point of the same inlet valve turn the fl
a little more than half a revolution until the mark 1-4 I C a
on top and registers with the punch mark on the cylinder.
the flywheel in this position the inlet valve should be close
after very slight movement of the flywheel to the left there
be enough space between the top of the valve plunger and th

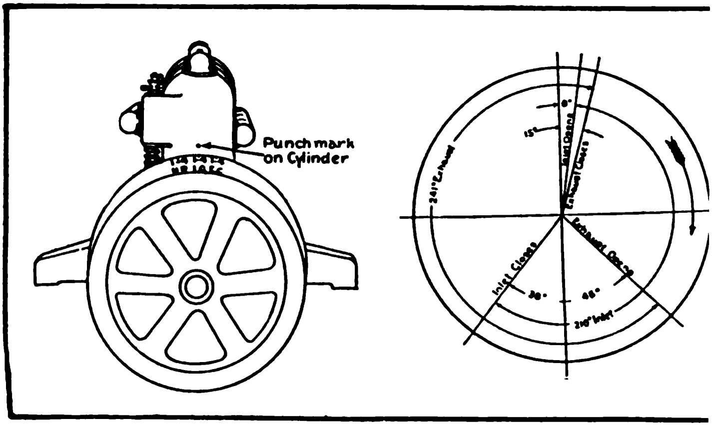


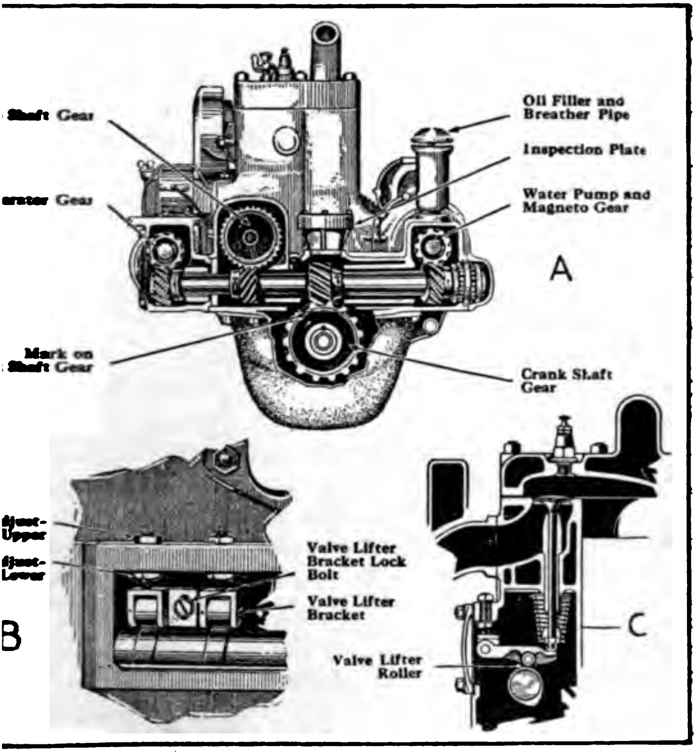
Fig. 148.—How the Overland Four Cylinder Motor Valves are T

valve stem to insert a thin visiting card. At the Overlan
tory this space is measured by a gauge exactly twelve thous
of an inch (.012) thick; this clearance is necessary to comp
for the expansion of the valve stem when it becomes hot
the operation of the engine. The exhaust valve opening in
cylinder is then gone over in the same manner. After the
where the inlet valve closes the flywheel is turned half a turn
the mark 1-4 Up comes to the top. Turn the flywheel to tl
until a mark indicated by 1-4 E. O. registers with the punch
in the cylinder. To determine the point of exhaust valve
turn the flywheel to the left for a space equal to 241 d
measured on the flywheel rim where a mark will be found
cating the point of exhaust valve closing, which will be 1-4
In order to enable the repairman to judge the amount of di

d on the flywheel circumference corresponding to the num-
legrees valve opening the following tabulation is given:

	Model 69	Model 71
ameter of flywheel	17 in.	18 in.
et valve opens late	$1\frac{3}{16}$	$1\frac{1}{4}$
et valve closes late	$5\frac{21}{32}$	$5\frac{31}{32}$
haust valve opens early	$6\frac{27}{32}$	$7\frac{15}{64}$
haust valve closes late	$2\frac{15}{64}$	$2\frac{23}{64}$

same instructions apply to 1915 four-cylinder motors.



—**Method of Timing Valves of Overland Six Cylinder Motor and Adjusting *Valve Gear.***

Remeshing Overland Model 82 Time Gears.—A cross shaft o front of the motor operates the generator and pump shaft. Thi shaft is driven by a bronze gear keyed to the front end of th crankshaft. The gear at the extreme left of the cross shaft (Fig 149) or right hand side of the motor drives the generator shaf The second gear from the left of the illustration drives the cam shaft. The gear at the right of the cross shaft drives the pum and magneto shaft which, like the cam and generator shaft, run parallel to the crankshaft. When these have been taken apart an are to be reassembled, follow these directions: Turn the flywhee until pistons 1 and 6 are on upper dead center, with No. 1 jus completing its compression stroke and ready to fire. On keyin the driving gear to the crankshaft, make sure that the straigh mark on the top of the gear is lined up with the bottom face o the cylinder casting.

Through the inspection plate you will notice a straight mar lengthwise of the cross shaft. This mark must line up with corresponding mark on the face of the inspection plate. Lir ing up the shaft, of course, automatically brings the four gear keyed on to the shaft in their proper positions. Now it is onl necessary to assemble the three driven gears so that the arro punched on the face line with the corresponding mark on th housing.

Timing the Valves.—This, too, is an operation which shoul be undertaken with caution and carried out with accuracy, an by a person competent to do such work. The rim of the flywhe bears at various points the following marks:

1-6 D-C means: pistons of cylinders 1 and 6 are in their utmost positio
2-5 D-C means: pistons of cylinders 2 and 5 are in their utmost positio
3-4 D-C means: pistons of cylinders 3 and 4 are in their utmost positio
1-6 I-O means: inlet valve of cylinder 1 or 6 opens.
1-6 I-C means: inlet valve of cylinder 1 or 6 closes.
1-6 E-O means: exhaust valve of cylinder 1 or 6 opens.
1-6 E-C means: exhaust valve of cylinder 1 or 6 closes.
2-5 I-O means: inlet valve of cylinder 2 or 5 opens.
2-5 I-C means: inlet valve of cylinder 2 or 5 closes.
2-5 E-O means: exhaust valve of cylinder 2 or 5 opens.
2-5 E-C means: exhaust valve of cylinder 2 or 5 closes.

-4 I-O means: inlet valve of cylinder 3 or 4 opens.
-4 I-C means: inlet valve of cylinder 3 or 4 closes.
-4 E-O means: exhaust valve of cylinder 3 or 4 opens.
-4 E-C means: exhaust valve of cylinder 3 or 4 closes.

The motor cylinders are numbered 1, 2, 3, 4, 5, 6, number 1 being the cylinder near the radiator and number 6 the nearest the dash. Cylinder number 1 fires first, number 5 next, then numbers 3 and 6, then 2 and 4. The timing of the valves is, perhaps, best understood by reference to the diagram. It will be seen that the intake valve opens when the flywheel is 7° 54′ past upper dead center and closes when it is 30° 6′ past the lower dead center. The exhaust valve opens 41° 2′ before the lower dead center and closes again 3° 51′ past upper dead center; thus the inlet valve opens and closes late, whereas the exhaust valve opens early and closes late.

The flywheel being 15½ inches in diameter, the following table gives the measurements in inches of the valve operation when laid out on the rim of the flywheel:

Diameter of flywheel	15½ inch
Inlet valve opens late	1.07 inch
Inlet valve closes late	4.07 inch
Exhaust valve opens early	5.59 inch
Exhaust valve closes late	.52 inch

To determine whether setting of the valves is correct, proceed as follows, beginning with cylinder number 1: Open the priming cocks over all exhaust valves, to make the turning of the flywheel easier. Turn the flywheel to the left until the mark 1-6 D-C is in line with the guide mark on number 6 cylinder. Now pistons 1 and 6 are at their highest points in their cylinders, or on upper dead center. About 1.07 inches to the right of mark 1-6 D-C you will notice the mark 1-6 I-O. Turn the flywheel to the left until this mark is lined up with the guide mark on the motor. At this point the inlet valve of either cylinder 1 or cylinder 6 should begin to lift. If the lift should occur in cylinder 6, turn the flywheel one complete revolution, until the mark 1-6 I-O *again appears on top* and in line with the guide

mark. Now watch or feel the inlet valve stem of cylinder 1; it should just begin to lift from its seat.

To determine the closing point of the same inlet valve, turn the flywheel a little more than a half revolution, until the mark 1-6 I-C appears on top. With the flywheel in its position, the inlet valve should be closed and there should be just enough space between the top of the valve-lifter and the valve stem that a thin visiting card can be placed between them. At the factory stem and lifter are set so that the distance between them is exactly four thousandths of an inch; this clearance is necessary to compensate for the expansion of the valve stem when it becomes hot during the operation of the engine.

If adjustment is necessary, loosen the lock-nut on the top of the valve lifter bracket and screw the lower nut up and down, as shown in B, Fig. 149. If the play between valve lifter and valve stem is too great, the result will be noisy operation; if the adjustment is too close, the valve may be prevented from seating fully. Next, test the exhaust valve, again bringing 1-6 D-C to the top, and turning the flywheel to the left until the mark 1-6 E-C appears in line with the guide. After you have tested the closing of the exhaust valve of cylinder number 1, test its opening by revolving the flywheel until the mark 1-6 E-O comes to the top. Then go carefully over the valves of cylinders numbers 6, 2 and 5 and 3 and 4. A slight variation of the flywheel markings to the right or left of the guide mark is permissible, but it should not be greater than a quarter of an inch.

There is hardly a repair shop in the world that will not have occasion to time the valves of a Ford motor. The firing order is 1—2—4—3 and the point of valve openings are clearly indicated in diagrams at Fig. 150. These show the points as measured directly by the piston travel and need no further explanation.

Marking Offset Cylinder Motor.—The instructions given for marking flywheels apply specifically to those engines in which the center lines of the cylinder and crankshaft coincide. If there is no offset the flywheel is marked from upper and lower dead centers, which also indicate the top and bottom positions of the pistons in the cylinders. With an offset crankshaft, the flywheel

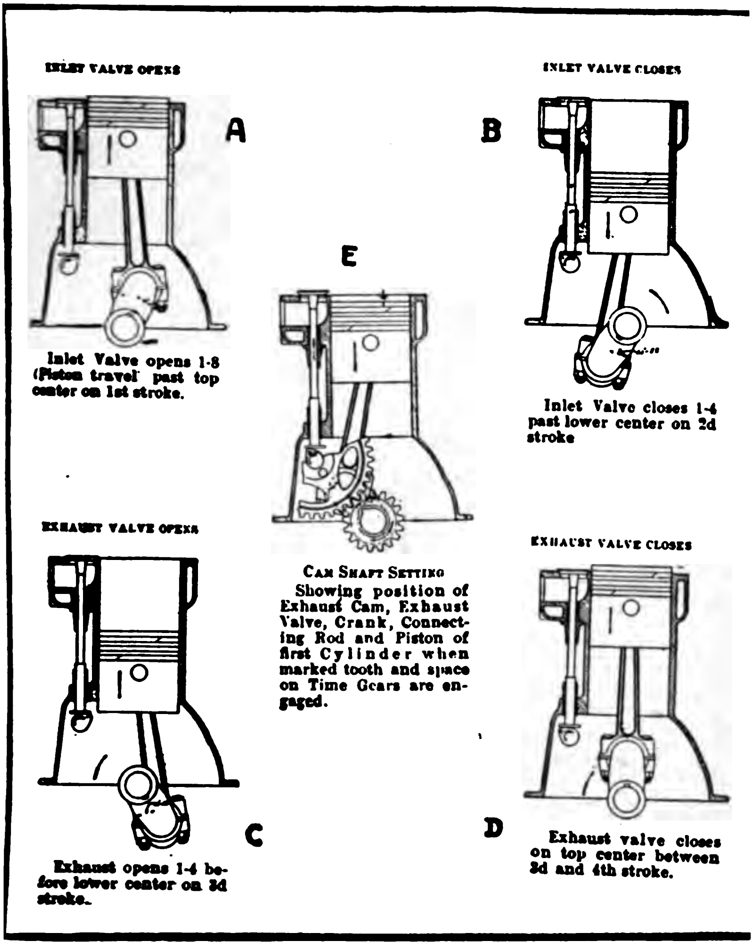


Fig. 150.—Methods of Timing the Ford Four Cylinder Motor.

marked at the upper vertical point by the angles laid off fr(at position of the piston, connecting rod and crankshaft whi ings the three centers into line, i.e., the piston pin center, t ank pin center and the center of the crankshaft bearing. T ason for this is that with the piston at its highest point

indicated by the usual method of finding upper center l ting the connecting rod vertically in the upper position, a s further movement of the crank which will bring the thre ters into line will raise it a small amount further, this being the true point of upper dead center. Similarly wi lower center when the connecting rod is at its lowest poi starts to rise sl the piston is not lowest point ar movement past until the three points mentione into line, will tinue to draw t ton downward a though meas amount. In the tration, Fig. 15 four stages of off-set engine shown. The p tions of this have been exagg to some exte clearly bring o points involved. cycle of the en followed throu the diagrams in sequence, this being inlet opening, inlet closing, exhaust ing and exhaust closing. In these diagrams the timing is: Inlet opens at 8 degrees past the upper center; inlet at 26 degrees past the lower center, making the total inlet ing 198 degrees; exhaust opens at 46 degrees before lowe ter, exhaust closes at 5 degrees past upper center, making th exhaust opening 231 degrees. If the engine timing differ *this and* the flywheel is not marked, with the points of o

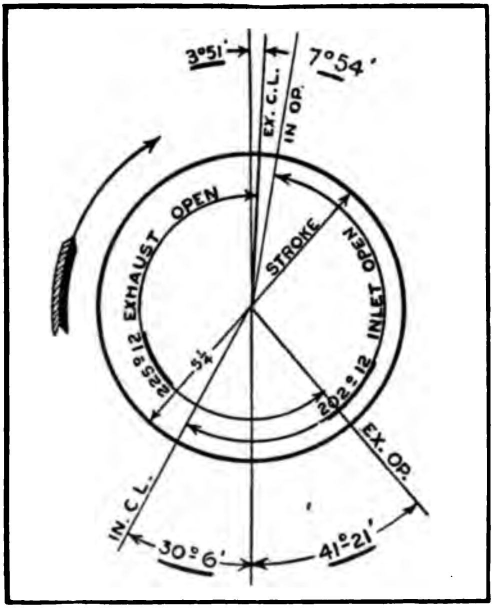
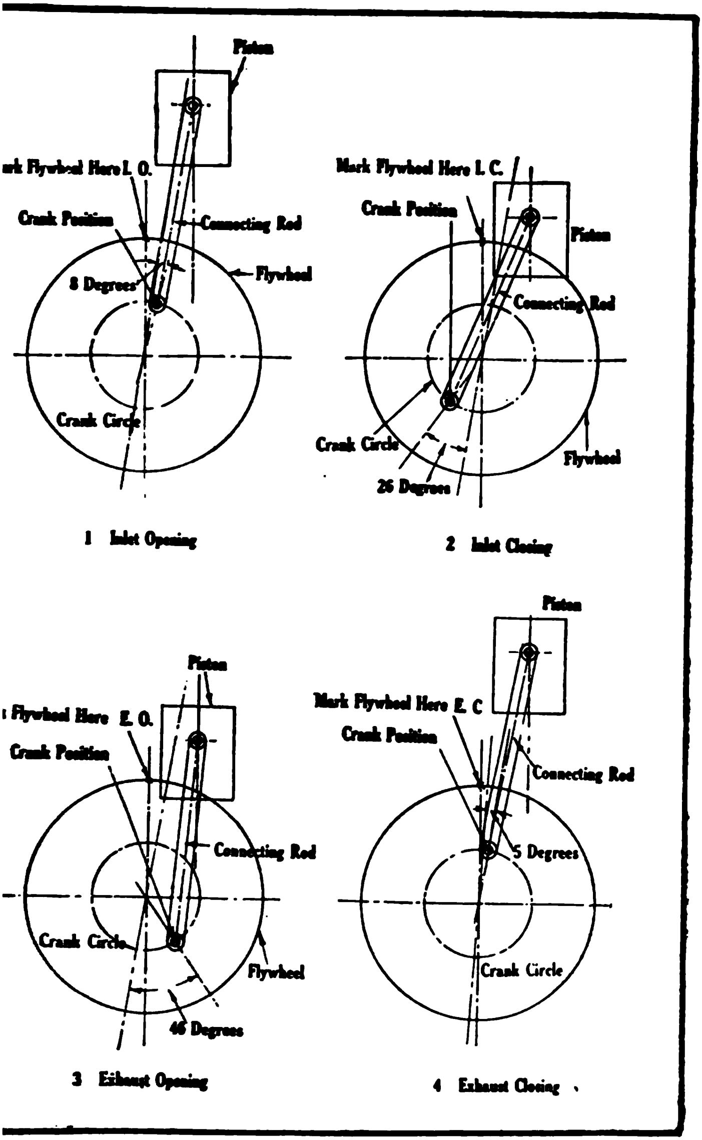


Fig. 151.—Diagram Showing Flywheel Marking on Overland Six Cylinder Motor.



—How to Mark Flywheels of Engines Having Offset Cylinders.

and closing given, it will not be difficult to mark the flywheel rim, though this is a job that must be carefully done. To simplify the explanation, we will assume that the motor timing is the same as indicated. The method of procedure is as follows: First, place the engine in a suitable position to work on and remove the lower half of the crankcase. Turn the crankshaft over slowly until the upper end of the connecting rod reaches the top point, then turn still more slowly, until the three centers are brought into line. This will be a somewhat difficult job to handle, but with care, assisted by the more usual method of placing a pointer in the top of the cylinder, resting on the piston, and moving up and down with the latter, this can be accomplished. Having the center, lay a straight edge across the crankcase lower edge, and set a protractor or other angle measuring device to the exact angle between this and the cheeks of the crankshaft. Now, take this protractor off, note the angle, and then add to this the angle of the inlet opening, eight degrees as above. Set this back on the straight edge and turn the crank until the cheeks coincide with the new setting of the protractors. Then mark the upper point of the flywheel with the initial letters I O, to indicate inlet opening. It is well to mark this at the time the work is done with prick punches which can be remedied afterward, scribing a line clear across the flywheel and then putting in the letters or the full words if desired.

Find the following lower dead center and mark the flywheel for that in the same manner. Then, nearly a full turn is necessary before the next lower center, from which the angle of the exhaust opening must be subtracted, this calling for a backward movement. No trouble need be experienced in the final exhaust closure point. In the sketch the marking is indicated to go on the center of the flywheel, that is, directly above the center line of the crankshaft. This is not necessary, the marks may be put anywhere desired, on the cylinder center line or elsewhere. A pointer of sheet metal should be made and fastened on the engine case somewhere, preferably under the nuts of the rear cylinder bolts, so as to point to the marks.

Two typical valve timing diagrams, one for a four cylinder *engine having a flywheel* diameter of 15¾ inches, the other of a six

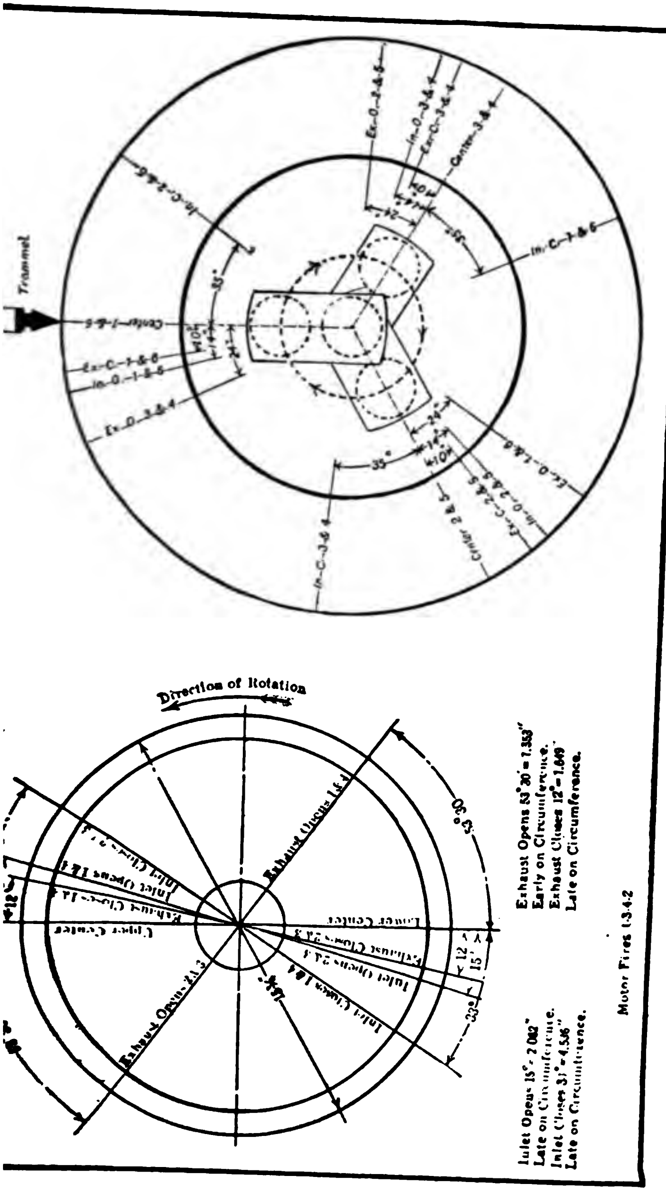


Fig. 153.—Typical Valve Timing Diagrams for Four and Six Cylinder Engines.

cylinder engine are given at Fig. 153. In the diagram at the left, which is that of a four cylinder motor having a firing order of 1—3—4—2, the points of valve opening and closing are not only indicated in degrees but also by the equivalent dimensions measured on the flywheel periphery. In the six cylinder engine diagram shown at the right the points are indicated measured in degrees.

In studying the table presented, it should be remembered that there are many conditions upon which valve timing depends, and a formula correct for one motor would not necessarily be satisfactory for another of the same size. In all cases, the inlet valve opens after the piston has reached the end of its exhaust stroke, the lag depending upon the size of the valve, shape of cam and motor speed desired. Most designers do not open the inlet valve until the exhaust is fully closed, but there are some who allow the valves to overlap; that is, the inlet valve starts to open before the exhaust is fully closed. It should be remembered that exhaust closing and inlet opening occur approximately after that point in the cycle where the piston reaches the end of its second up stroke. The inlet valve closes after the bottom of the suction stroke is reached, good practice being a lag of between 30 and 40 degrees crank travel. The exhaust valve opens before the piston reaches the end of its down stroke under the influence of the explosion. The lead may be as high as 60 degrees crank travel before center, but this is an extreme case. Good average practice is covered in the range between 40 and 45 degrees lead.

The reason for having the exhaust valve closing and inlet valve opening overlap is that this takes advantage of the momentum of the exhaust gas and results in clearing the cylinder more positively than if the valve closed absolutely on center. During the final period of valve closing but little space is present for the escape of gases. If the valve closed positively on upper dead center, the area of the port or passage would be small for an appreciable upward movement of the piston when it neared the top of its stroke, and more inert gas would be retained in the cylinder than if the valve was closed after the piston starts down on the intake stroke.

The following table outlines the valve timing of a number of standard American automobile motors.

VE TIMING OF SOME TYPICAL AMERICAN CARS
FROM S.A.E. DATA SHEET, No. 53, VOL. I

r	Intake Opens Deg. Min.	Intake Closes Deg. Min.	Exhaust Opens Deg. Min.	Exhaust Closes Deg. Min.
	11.30	49.12	45.48	11.30
	17.53	29.25	42.36	8.20
	4.20 to 14.20	38.26	31.34	7.00
	13.00	30.00	50.00	13.00
	12.00	33.00	55.00	12.00
	14.00	39.00	49.30	12.00
	13.00	49.00	47.00	9.00
, H-4	16.48	54.08	27.13	14.06
ïo. 4	8.00	33.00	51.30	17.00
	5.00	35.00	47.00	2.00
	5.00	35.00	37.00	2.00
	21.00	28.00	46.00	16.00
	15.00	38.00	45.00	10.00
	18.00	46.00	47.00	15.00
	18.00	46.00	47.00	15.00
	9.44	30.38	32.10	5.00
	15.00	30.00	45.00	5.00
	10.00	40.00	60.00	on
	5.00	40.00	35.00	on
	6.00	32.00	43.00	6.00
	10.00	28.00	40.00	2.30
!	14.00	24.00	31.00	21.00
	15.00	38.00	45.00	10.00
36	9.40	32.30	41.50	11.40
25	9.40	32.25	40.30	12.00
tle 6	10.00	28.00	40.00	2.30
	18.00	36.00	53.30	14.00
I.C	10.00	28.00	40.00	2.30
	7.00	36.00	43.00	12.00
	15.00	30.00	45.00	10.00

he space between the valve stem and the valve lifter .n it should be there are two methods of compensating preciation. On many small motors no adjustment is etween the valve stem and the valve stem plunger. The the Ford car advise drawing the valve stems out until space exists between the push rod and the stem. It is when drawing out the stem or lengthening it not to bend em, as this will result in the valves sticking, or in any bore of the valve stem guide in the cylinder will be nly. *The clearance between* the pushrod and the valve

stem should never be greater than $\frac{1}{32}$-inch nor less than $\frac{1}{64}$-incl If too much clearance is present the valves will open late an close early. If the clearance is less than the minimum there i danger of the valve remaining partially open all of the time be cause the valve stem lengthens, due to expansion produced by th heat of the explosion. When it is necessary to draw down a valv stem this should be done by peening it for about $\frac{3}{4}$-inch abov the pinhole or key slot.

It is not a difficult matter to set the clearance exactly as i should be on those types of engines provided with an adjustmen screw which may be raised or lowered in the valve plunger or i forms having fiber inserts in the top of the valve plunger. Thes inserts are utilized to silence the valve action and may be easil removed and replaced with new ones when worn. A simple an cheap accessory that can be obtained on the open market can b used to adjust the clearance on Ford and similar type motor This consists of a number of stamped steel cups that can be pushe on the lower portion of the valve stem and a number of thin stee washers to be interposed inside of the cup and between the bot tom of that member and the end of the valve stem to regulat the clearance as desired.

Sleeve Valve Motors.—A number of automobile manufacturer have adopted the Knight sleeve valve motor as a power plant The same instructions that have been given regarding the time o opening and closing of the valves of other motors also apply t this form in a limited degree. The only possibility of losing th timing on the sleeve valve motor, which is shown in section a Figs. 154 and 155, is by faulty setting of the sleeve operatin crankshaft, in its relation to the main crankshaft. If the timin is altered by depreciation of the bearing in the sleeve operatin links they may be refitted; the lower or rotating bearings whic would be more apt to wear than the upper or oscillating bearing are of the same marine pattern as is generally used in the mai connecting rod. This means that any depreciation may be rem died by fitting the bearing caps closer to the connecting rod an scraping or reaming to fit.

In order to show clearly the appearance of the various par

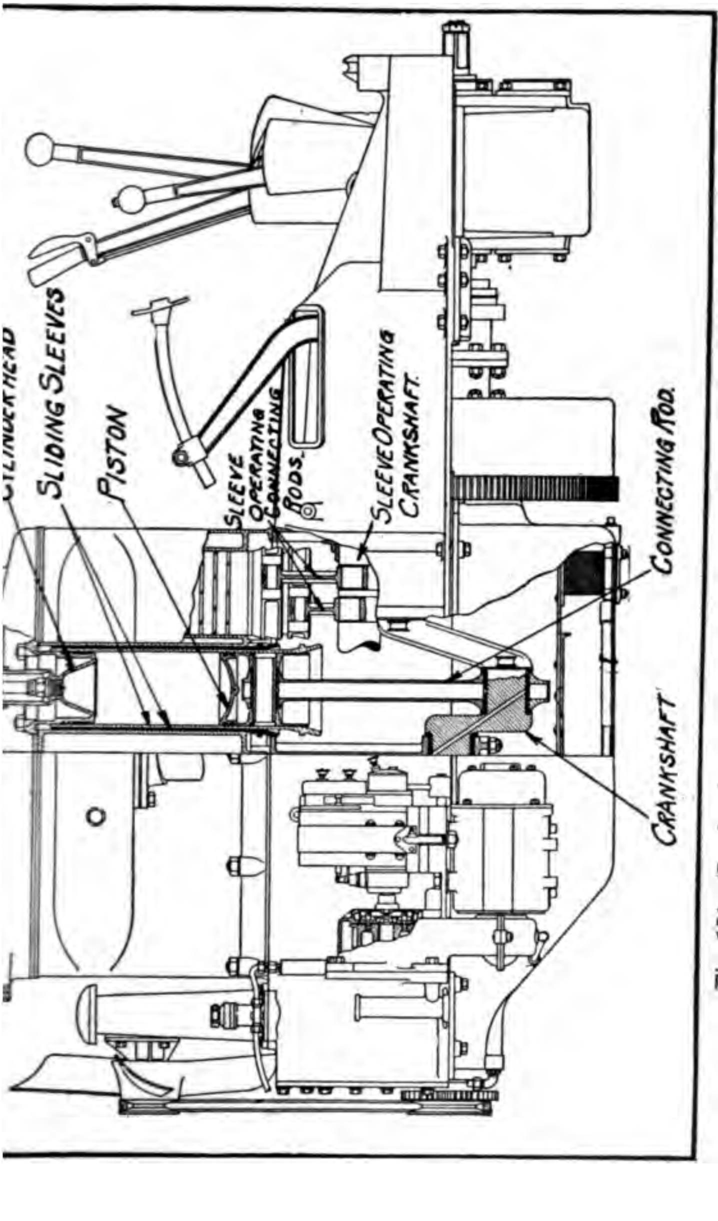


Fig. 154.—Sectional View of Knight System Sliding Sleeve Valve Motor.

of the sleeve valve mechanism the views at Fig. 156 are pre
At A, the cylinder heads which have just been removed fr
cylinder block B, are depicted. The connecting rod, pisto
the two sleeve valves in one assembly just as it is removec
the cylinder inte
shown at C. Tl
ton and connecti
removed from t
terior of the ins
long sleeve is sh
B, the inside o
sleeve is outlined
and the short sl
shown at F. It
apparent that tl
passages which
the form of slo
into the upper p
of the sleeve wal
not apt to char
size except the
small amount d
the deposit of c
in the port ope
Obviously they n
restored to full s
scraping away th
terial.

The illustratic
Fig. 157 will
clearly the relati
the two sleeves
the cranks ope
them, while the
of views at the
will show the wa
various ports re

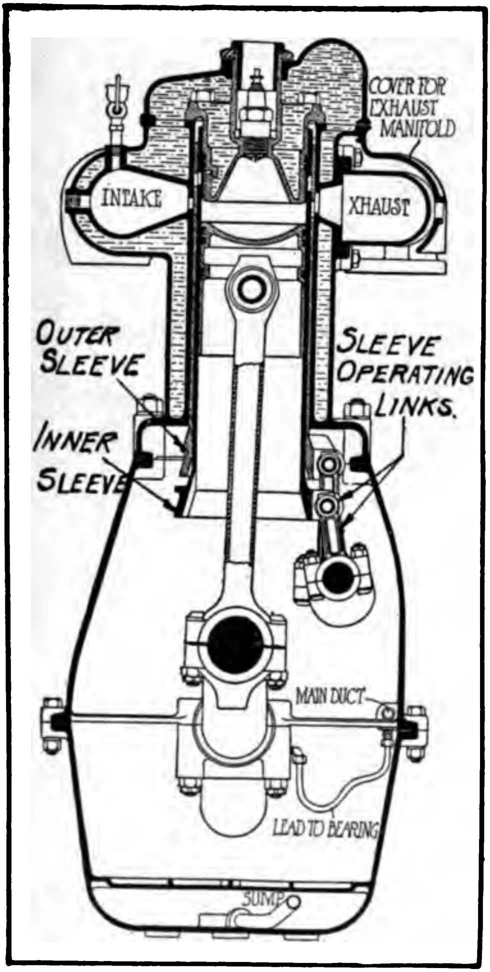
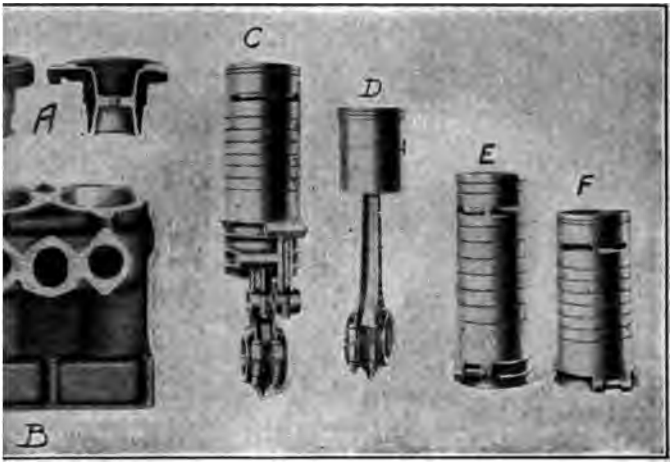


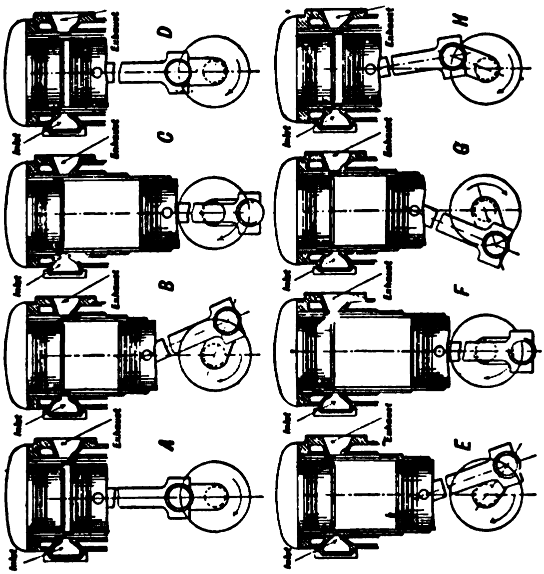
Fig. 155.—Showing Application and Method *of Operation of* Sliding Sleeve Valve.

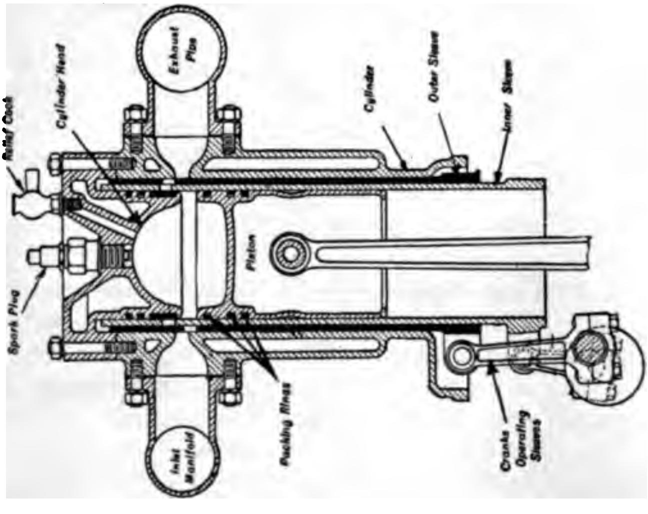
a clear passage for the ingress or egress of the gases. At ton is shown at top center, the exhaust ports have just the inlet ports are just about to register and permit the into the cylinder as the piston descends on its suction



ig. 156.—Parts of Sleeve Valve Cylinder Assembly.

t B, the piston is seen nearing the end of its stroke and ort is fully open. The exhaust port is completely closed. hown the end of the intake stroke with the inlet ports g. The view at D, shows the piston at the end of its n stroke with both inlet and exhaust ports closed. At on has gone down the greater portion of its power stroke xhaust openings in the inlet and outer sleeves are just to meet and register with the exhaust outlet port in the At F, the exhaust port is about half open, at G, the ex- is fully open. The piston and crank position at H, in- closing of the exhaust port. The inner and outer sleeves cannot vary in timing which is determined by the dis- the throws on the sleeve operating crankshaft. If for the proper relation of rotation between the main crank- the member operating the sleeve valves is lost one may ylinder No. 1 *and time the engine* in somewhat the same


Inlet
Exhaust
A
B
C
D
E
F
G
H


Spark Plug
Relief Cock
Cylinder Head
Exhaust Pipe
Cylinder
Outer Sleeve
Inner Sleeve
Piston
Packing Rings
Inlet Manifold
Cranks Operating Sleeves

manner as the poppet valve motor is timed. The instructions given for setting the sleeve valve of the Lyons-Knight motor are: the intake opens 10 degrees after top dead center and closes 40 degrees after the bottom dead center. The exhaust valve opens 60 degrees crank travel before the piston reaches the end of its power stroke and closes on dead center.

One peculiar point about the sleeve valve motor in which it differs radically from the poppet valve type is that the carbon deposits which are very detrimental to proper poppet valve operation are said to be actually beneficial to the operation of sleeve valves because the carbon on the sleeves has a certain lubricating value. Instead of endeavoring to prevent carbon accumulation all sorts of expedients are tried in the various plants where sleeve valve motors are manufactured to assist carbon accumulation. Mr. Charles Y. Knight the inventor of this type of motor writes as follows regarding the formation and utility of carbon in sleeve valve motor operation:

"Providence seems in the case of the sleeve valve to deposit the carbon just where it is required, rectifying any small errors in clearances or adjustments or small ring leakages which may have crept into the construction. And the user is advised to be most careful about its removal—not to interfere with the deposit unless through some extraordinary conditions the character of the accumulation partakes of the scale-like formation which upon severe use of the motor becomes incandescent, as shown by its brown color and projecting scale-like form. Happily, such scale is seldom encountered, and when it may have formed as a result of the cause described, the user is advised to remove it, not with the use of a sharp-edged metal tool, but by employing a coarse, rough piece of fabric, which when rubbed heavily upon the surface to be cleaned, will serve to carry away the loose flakes, which could possibly cause self-ignition, without exposing the polished surfaces of the head and piston. A carbon deposit upon the cylinder head rarely takes the form of scales because of its perfect cooling.

"My observation leads me to believe that the tendency to carbonize is growing with the lowering in the grade of the petrol supplied for fuel purposes. *In short,* it is my experience, sup

ported by the judgment of many others with whom I am associate
that the principal source of carbon deposit is the imperfect con
bustion experienced regularly upon the road with all carburete
and engines. It is doubtless true that road dust and lubricatin
oil have a considerable influence in the accumulation of carbo
upon the surfaces of the explosion chamber and head of the pisto
and valves in an indirect manner, but the carbon itself, I am co
vinced, comes largely from imperfectly consumed fuel. The lubr
cating oil furnishes the moist element which collects and holds th
gasoline carbon from the time of the occasional periods of impe
fect combustion until it is thoroughly burned on by later highe
temperatures under full throttle.

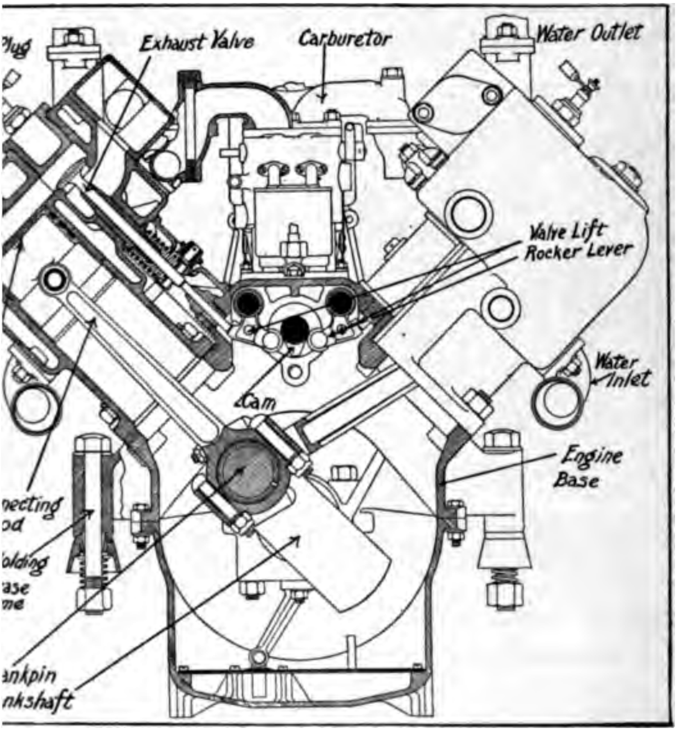
"Attention is properly called to the fact that the sleeve val
engine, while it shows as great thickness of carbon deposit as th
poppet valve, does not suffer from its presence, and makers of th
latter are admonished to study the cause of the poppet valve'
serious defect. It is also asserted that the two-stroke engine, a
well as the sleeve valve, is free from the damaging effects of th
carbon deposit, but no explanation of this condition is vouchsafed

"That the conclusions of these authorities are well based is evi
dent from the fact that every owner of a sleeve valve motor wil
testify that the power and sweet running of his engine *increase*
with use, which fact has caused a great deal of speculation.

"A limited carbon deposit accomplishes two things: First, i
increases to a limited extent the compression by reducing the com
pression space. Second, the coat of carbon acts as an insulato
and prevents the transmission of heat from the piston top an
cylinder head, which heat, instead of wasting through these wall
into the cooling water or base chamber, is put to useful work. I
the limited extent of this accumulation lies the secret of the nor
knocking of the sleeve valve motor."

Timing 8 Cylinder V Motors.—Several cars of 1915 design wi
be found to incorporate 8 cylinder V motors of the general forn
shown at Fig. 159. These have two blocks of four cylinders eac
mounted on a common crankcase and disposed as shown in order t
reduce the length of the engine. While the power plant shown
a French design, the American engines of the same type follow th

on indicated very closely. The best arrangement of the is with the center lines disposed at an angle of 45 de- n the vertical center line of the motor. This indicates ylinder center lines are separated by an angle of 90 de-



'ig. 158.—Eight Cylinder V Engine of DeDion Design.

his arrangement makes it possible to operate 16 valves t cams. The method of valve operation is clearly out- Fig. 160, the view at A being enlarged to show the dis- of the valve plunger lifters or cam riders in relation to aft. The valve stem clearance may be regulated as de- the conventional pattern of adjusting screws. The same ns that *apply to timing* a four cylinder motor may be

followed in setting the valves of an eight cylinder form, th(precaution to be observed is that the cylinders will fire i proper order.

Views at Fig. 163 show the relative movements of the for a quarter revolution of the crankshaft. At A, the cran position is such that the cylinders on one side are starting to tion just as would be the case in a four cylinder motor wi

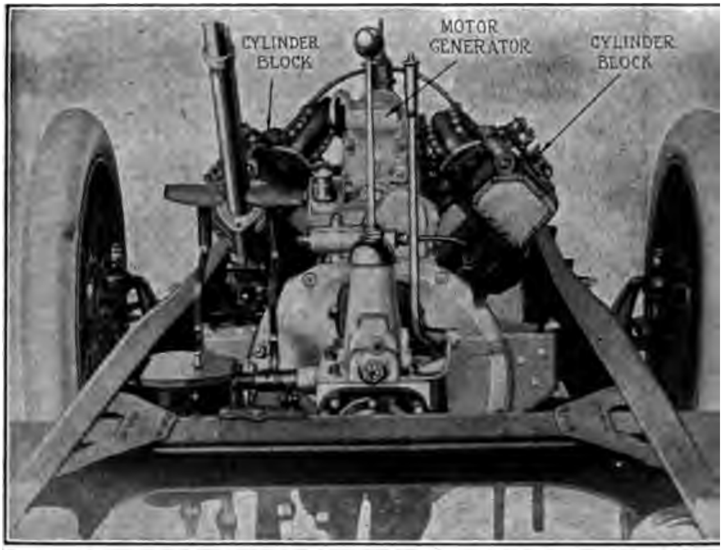
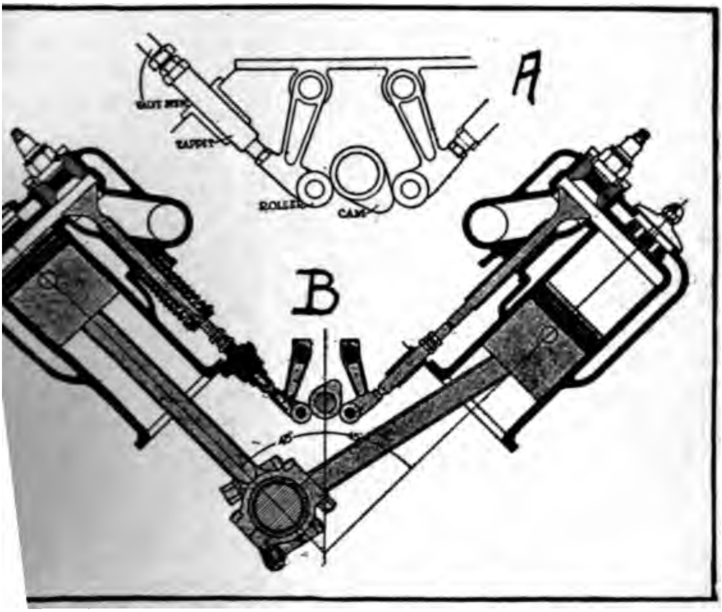


Fig. 159.—Rear View of Cadillac Eight Cylinder V Engine Inst in Frame.

crankshaft vertical, i. e., two pistons are at the bottom of the and two pistons are at the top. Rotating the crankshaft 4 grees or $\frac{1}{8}$ of a revolution produces the condition outlined In this none of the pistons are at the top of the stroke. Ro the crankshaft another 45 degrees gives us the conditions at C, which is the opposite to that outlined at A. The or(firing in the Cadillac motor which is one of the most popu as follows: No. 1 cylinder on the left fires first; then No. 4 *der on the* right; No. 3 left and No. 2 right; then No. 6 c

t, No. 7 on the left; then No. 8 on the right, and lastly No. he left. It is possible to have the valves in an eight cylinde



—How Valves of Cadillac, Eight Cylinder V Engine, are Operated.

en in quite a variety of ways as consideration of the fol- ssible firing orders will indicate:

OSSIBLE FIRING ORDERS—8-CYL. V TYPE, 90°

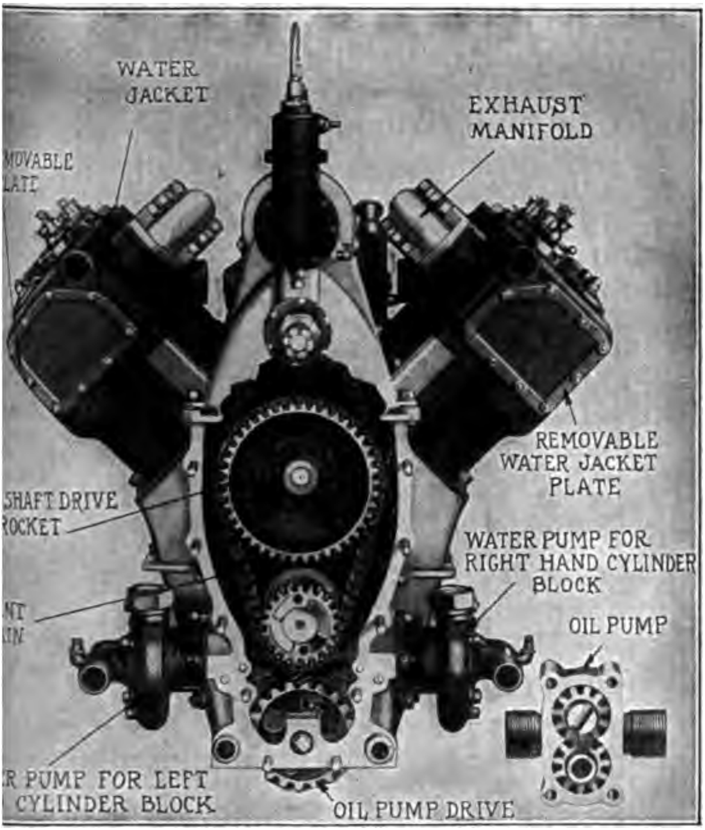
1 R—1 L—2 R—2 L—4 R—4 L—3 R—3 L
1 R—1 L—3 R—2 L—4 R—4 L—2 R—3 L
1 R—1 L—2 R—3 L—4 R—4 L—3 R—2 L
1 R—1 L—3 R—3 L—4 R—4 L—2 R—2 L
1 R—4 L—2 R—3 L—4 R—1 L—3 R—2 L
1 R—4 L—3 R—3 L—4 R—1 L—2 R—2 L
1 R—4 L—3 R—2 L—4 R—1 L—2 R—3 L

icates right-hand block. L indicates left-hand block.
lers numbered from *front to rear*—1, 2, 3, 4.

When one cam serves two opposite valves, there is onl practical timing, the inlet must open on top center and cl degrees after bottom center; the exhaust valves must open grees in advance of bottom center and close at top center. King eight cylinder motor, if we call the first cylinder o right No. 1, the second on the right No. 2, and so on and th on the left No. 5, the next on the left No. 6 and so on, the order will be 1, 8, 3, 6, 4, 5, 2, 7, or using the other method each cylinder block is numbered from No. 1 to 4 we have a order as follows: 1R—4L—3R—2L—4R—1L—2R—3L, th in preceding table.

How Silent Chains Are Adjusted.—The tendency to e chains for driving the shafts for valve control and for the m as well as for the gearbox, which originated in England is f some favor in France and America. The technical opini many experts leans strongly to the idea that all the adva of silent chains can be attained by using miter or herringb even straight spur gears, if only close attention is paid to tl rect shaping of the gear tooth curves in each case. As a of complying with the inscrutable dictates of automobile f some activity is displayed, however, among automobile ma turers to get the benefit of the experience with the chains has been gained in England. In this respect the precautions must be taken to obviate the effects of that lengthening b to which all chains are subject, come in the first line. Th constitute the most important objection to the adoption of First, a considerable initial stretch must be affected in each unless this is done in advance and at some additional cost chain maker, by running it under load for a short time on a machine established for that purpose, and subsequently tl mal wear of the chain pins and bushings, after the chain h placed in commission in a car, determines a further lengtl much smaller in percentage than the initial stretch but ye enough that it cannot be neglected.

If a chain is used that is larger than is needed, as Cadillac eight cylinder V type engine shown at Fig. 161, it *necessary* to provide adjusting means because the chain w



61.—Method of Driving Camshaft of Cadillac Eight Cylinder Motor by Silent Chains.

a if it is not stressed unduly, the strain being very much by using a wide chain having a margin of safety greater ually allowed in components of this kind. Where the apt to lengthen due to wear in the link plates and rivets, ovision must be made for adjustment. The practice of ıropean designers may be considered of value in this con-

e methods *are illustrated in Fig. 162.* Armstrong, Whit-

worth & Co. (A), provide an eccentric sleeve adjustment magneto shaft giving a maximum of 6 millimeters lateral d ment. Gregoire (B), uses two eccentric sleeves, so that down movement of the pinion can be avoided, probably view to leaving the valve timing entirely unaffected.

Chenard-Walcker (C), pushes the whole sprocket pinic ing as well as the baseplate of the magneto outwardly in

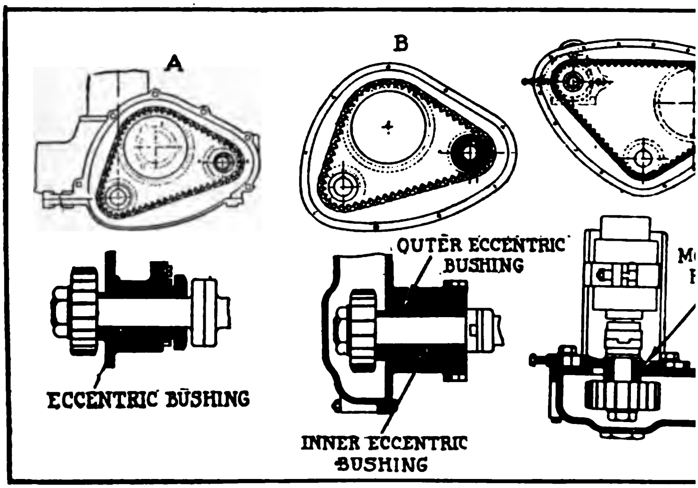


Fig. 162.—How Silent Chains may be Adjusted for Wear.

linear movement by means of a drawbolt, locking the adj with setscrews.

The method used on the King engines of this form is shown in accompanying front view of the motor with timi case cover removed. A pinion mounted on a slotted plat is adjustable can be moved to take out any slack in the (desired.

Precautions in Reassembling Parts.—When all of th tial components of a power plant have been carefully look and cleaned and all defects eliminated, either by adjust replacement of worn portions, the motor should be reas *taking care to* have the parts occupy just the same relati

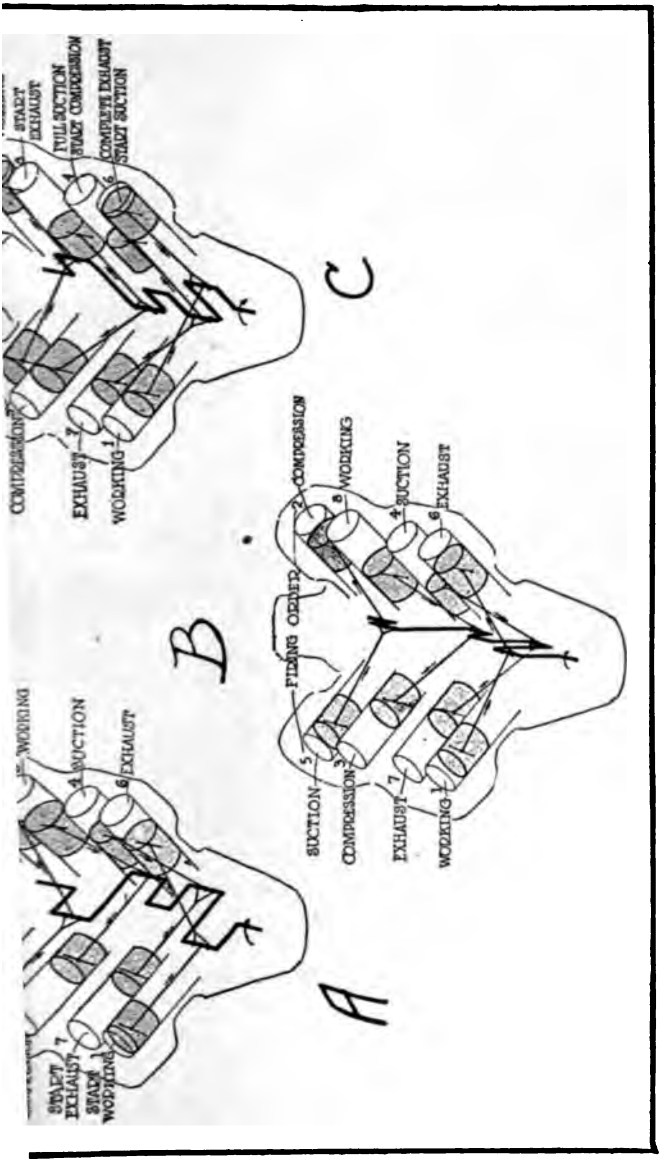


Fig. 163.—Diagrams Showing Movements of the Piston for Different Positions of the Crankshaft in Eight Cylinder V Motor.

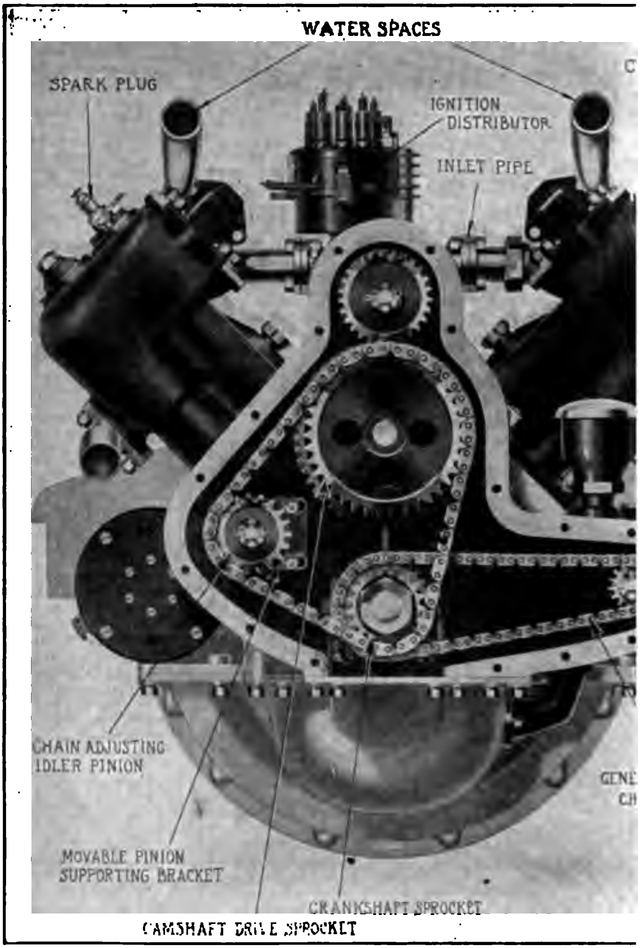
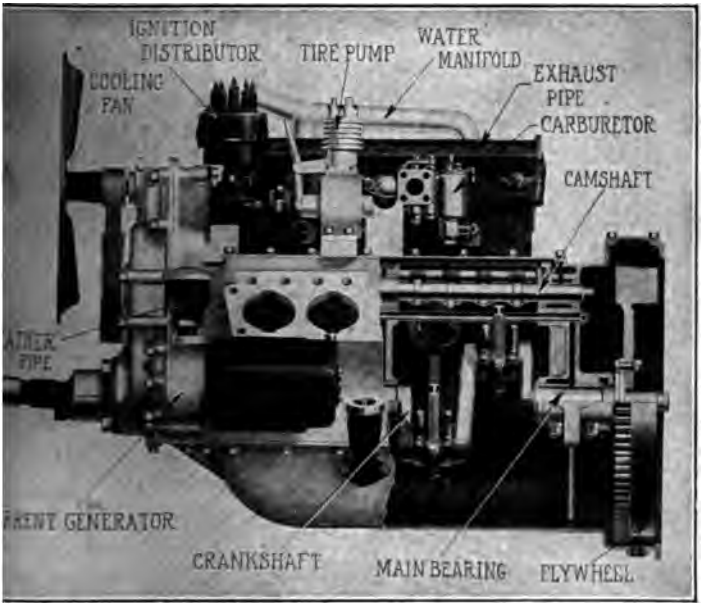


Fig. 164.—Front View of King Eight Cylinder Motor.]
of Camshaft Drive Chain Adjustment.

tions they did before the motor was dismantled. As added to the assemblage care should be taken to insı lubrication of all new points of bearing by squirting *tities of cylinder* oil upon them with a hand oil caı

led for the purpose. In adjusting the crankshaft bearings n them one at a time and revolve the shafts each time one : bearing caps is set up to insure that the newly adjusted ig does not have undue friction. All retaining keys and must be positively placed and it is good practice to cover a part with lubricant before replacing it because it will not



.65.—Longitudinal Part Sectional View of King Eight Cylinder Motor, Showing Important Parts.

ive in easier but the part may be removed more easily if y at some future time. If not oiled, rust collects around it. n a piece is held by more than one bolt or screw, especially a casting of brittle material such as cast iron, the fastening ould be tightened uniformly. If one bolt is tightened more : rest it is liable to spring the casting enough to break it. washers, check nuts, split pins or other locking means lways be provided, especially *on parts* which are in motion

or subjected to a load. Before the cylinders are replaced on t engine base, heavy brown paper gaskets should be made to place b tween the cylinder base flange and top portion of the engine cra case. The best method of making these gaskets is to tamp th out by placing the sheet of brown paper over the mouth of t cylinder and directing a series of light blows with a machinist ball peen hammer against the sharp edges of the casting. Th will cut the paper exactly to the form of the base flange and cyli der bore. The holes in the flange may be indicated in the sa manner or may be punched through with a steel drift. The sa process may be used in making irregular shape gaskets of ot materials such as asbestos or rubber packing.

Before placing the cylinder over the piston it is imperati that the slots in the piston rings are spaced equidistant and t the piston is copiously oiled before the cylinder is slipped over When reassembling the inlet and exhaust manifolds it is well to only perfect packings or gaskets and to avoid the use of those seem to have hardened up or flattened out too much in servic it is necessary to use new gaskets it is imperative to employ at all joints on a manifold because if old and new gaskets a together the new ones are apt to keep the manifold from b properly upon the used ones. It is well to coat the thread bolts and screws subjected to heat, such as cylinder head haust manifold retaining bolts with a mixture of graph oil. Those that enter the water jacket should be cover white or red lead or pipe thread compound. Gaskets wi better if coated with shellac before the manifold or oth are placed over them. The shellac fills any irregulariti joint and assists materially in preventing leakage after the made up and the coating has a chance to set.

In replacing cylinder head packings on cars like the is well to run the engine for a short while, several minut most, without any water in the jacket in order to heat t up thoroughly. It will usually be found possible to tight a little more on all of the cylinder head retaining bolts aft is done because if the gasket has been coated with shellac t *plus material* will have burnt off and the entire packing

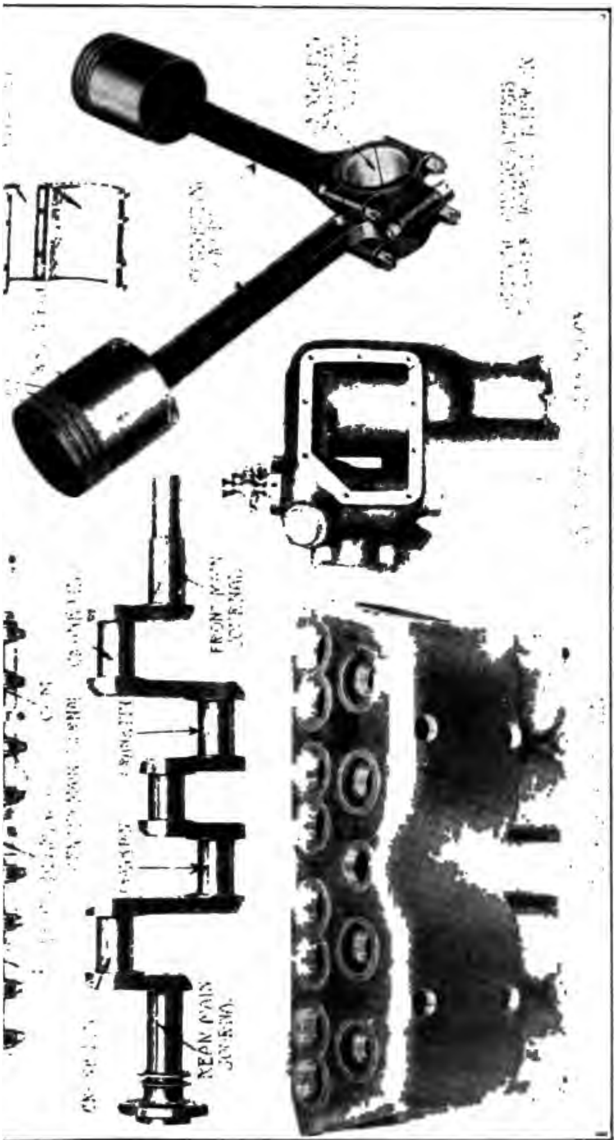


Fig. 166.—Group of Parts of Cadillac Eight Cylinder V Motor, Showing Construction of Important Members of Assembly.

down. Care should be taken when using shellac, white or r lead, etc., not to supply so much that the surplus will run into t cylinder, water jacket or gas passages.

Loose Flywheel.—Many mysterious knocks, which are oft attributed to worn bearings are due to the flywheel being loose the shaft. In a number of the earlier forms of cars and in near all marine engines the flywheels are held to the shaft by a simp gib key. It often happens that these keys become worn and tl wheel is slightly loose on its supporting shaft. When the engine revolving at high speed a pronounced thump or knock will be pr duced because of the hammering action of the flywheel upon tl loose key. The proper remedy for such a condition is to make new key that will fit the keyways in flywheel and shaft and dri it tightly in place. In some constructions the flywheel is i stalled on a taper on the crankshaft and in addition to the ke it is held in place by clamp nuts. These nuts sometimes becon loose and permit the flywheel to back off the taper enough produce noise. In practically all modern forms of motor the fl wheel is secured to a flange forged integrally with the cranksha by means of bolts. It may be possible for the bolts to loosen whi will permit the flywheel to rock and to pound the holes out ove This condition is easily remedied by reaming or drilling the wo holes to the next largest standard size and to fit larger bolts correspond.

Two Cycle Motors.—This form of power plant has receiv but limited application in automobiles, but the repairman may ha occasion to investigate irregular action of some old model c using this type of motor or may be called upon to repair a mari engine of this type. It will be evident that a worn cylinder, pist rings or piston will result in the loss of compression as in any mot and that loose connecting rods or main bearings will produce noi operation just as in the four-cycle type. In the two-cycle moto there are other conditions to be looked for besides those involvi normal depreciation of the mechanism. There are two chamb to keep tight instead of one as in the four-cycle type. In the tw cycle form it is not hard to maintain compression in the combusti chamber because there are no valves to leak and the only cha

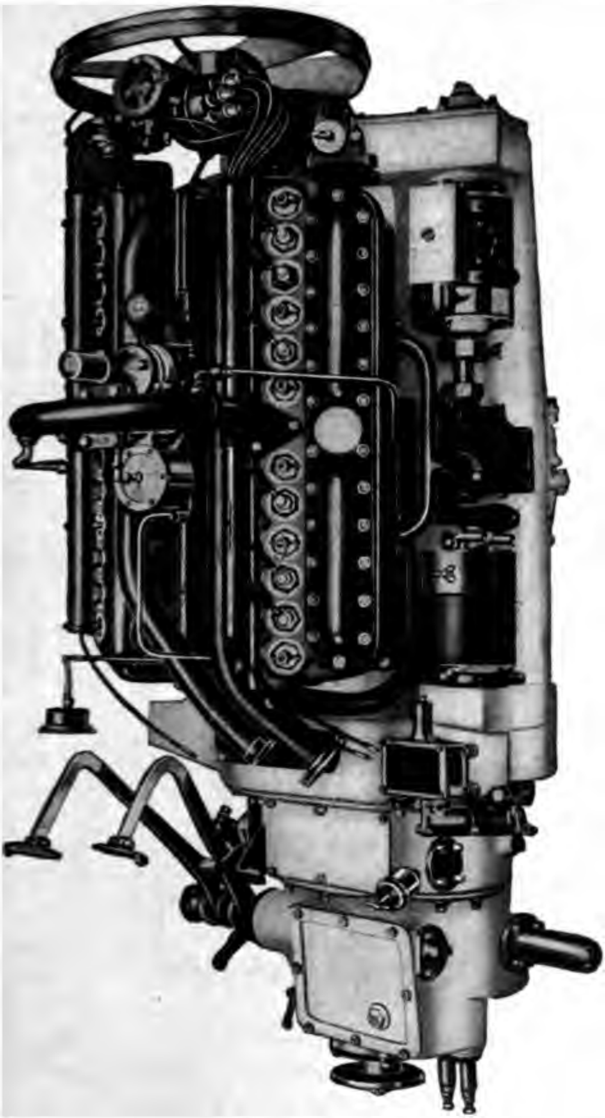


Fig. 167.—Packard "Twin Six" Motor, Latest Power Plant Development.

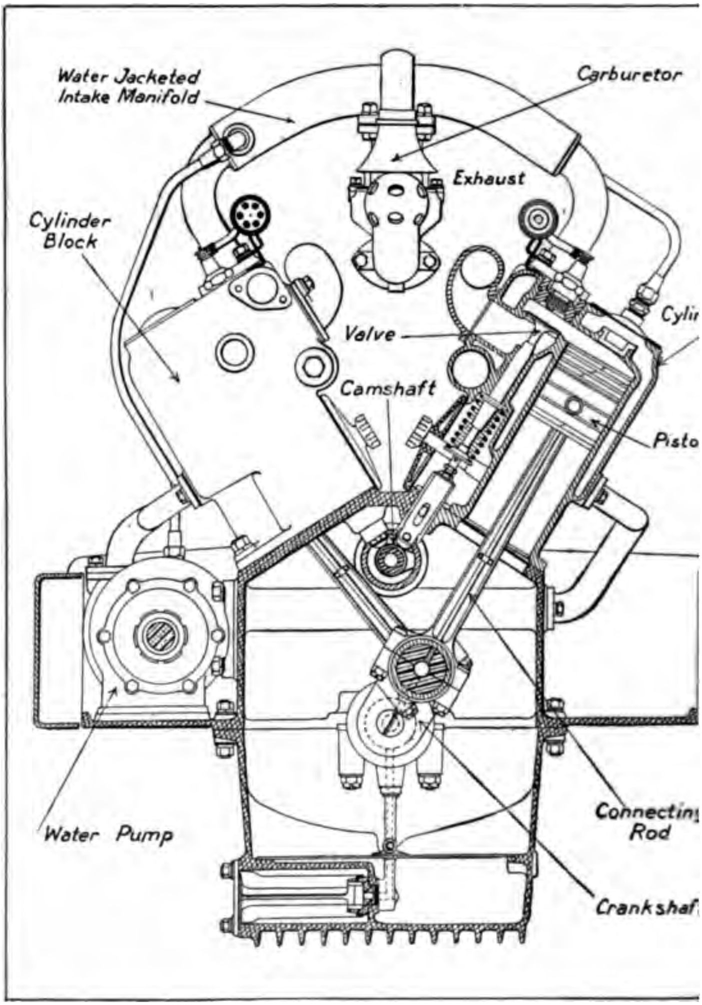


**Fig. 168.—End Sectional View of Packard "Twin Six" Motor, S
Arrangement of Cylinders.**

for escape is by worn piston rings. It is imperative, however, that a certain amount of compression be maintained in the crank case of most two-cycle engines because the degree of compression in the crank case determines the rapidity of transfer of explosive gas from the base where it is first received to the combustion chamber where it is exploded. Because of this the main bearings demand more attention than do those of a four-cycle engine because they must be fitted so well that there is no possibility of leakage through them. Similarly the packings between the cylinder and engine base and between the crank case halves must be carefully maintained. In examining the piston and cylinder care must be taken to remove any deposit of carbon from the baffle plate or deflector which is usually cast integral with the piston top, as any sharp point or corner would remain incandescent and would cause either base firing or premature ignition. Base firing is generally prevented by making the charge from the crank case pass through wire gauze in the by-pass passage. This prevents the flame igniting the explosive gas in the engine base because practically all of the heat is abstracted from any heated gas as it passes through the mesh of the screen. These screens sometimes become clogged with oil and reduce the speed of gas flow and consequently diminish the power output of the motor, the remedy is a simple one as it involves only the removal of the clogged screens and cleansing them thoroughly in gasoline before replacing.

The 12 Cylinder V Motor.—The last word in automobile motor construction is the "Twin Six" motor shown at Figs. 167 and 168. This is very much the same in construction as the eight cylinder forms, one marked difference being in the angle between the cylinders which is 60 degrees and in the use of crankpins wide enough so connecting rod big ends of two opposite cylinders may be placed side by side. Except for the multiplicity of parts which involves slight structural changes, the same instructions given for the repair of the simpler four cylinder engines apply to similar components of the eight and twelve cylinder power plants.

CHAPTER IV

COOLING, CARBURETION AND LUBRICATION SYSTEM FAU

Overheating—Systematic Location of Troubles—Deposits in Radiator Piping—Cleaning Sand from Water Jacket—Deterioration of Ru Hose—Pump Forms and Troubles—Methods of Fan Adjustment—La Flat Fan Belts—Utility of Hose Clamps—Restoring Broken Water —Radiator Repairs—Defects in Carburetion Group—Gravity Feed tem—Stewart Vacuum Feed—Air Pressure Fuel Feed—Air Pump struction—Auxiliary Tanks—Exhaust Gas Pressure—Faults in buretor Float Chamber—Troubles in Mixing Chamber—How to Float Level—Effect of Air Leaks—Typical Carburetor Adjustme Kingston—Schebler—Browne—Overland Schebler—Breeze—Stroml Holley—Krice—Zenith—Rayfield—Speed Governors—Carburetor In lation—Soldering Metal Floats—Emergency Manifold Repair—Si Oiling Systems—Typical Engine Oiling Method—The Constant L Splash System—Forms of Oil Pumps—Where to Look for Troubl Lubrication Systems—Cleaning Sight Feed Glass—Curing Smoking tor—Practical Oil Filter—Requirements of Lubricating Oils.

THE automobile power plant includes various auxiliary syst which are essential to motor action, and defects in these groups materially influence the power output and regularity of runn of the engine. Those that are usually grouped together are cooling, carburetion and lubrication systems, because defects in one of these may produce exactly the same effect on power pl operation. For instance, if the cooling system is not functio properly this condition will be evidenced by overheating. engine will run hotter than it should if lubrication is not adeq owing to friction which produces heating just as lack of pr cooling facilities will. If the carburetor supplies too rich mix the engine will show this condition by running hotter than it sh normally.

Systematic Location of Troubles.—When a motor overhe *is not possible to* discover immediately whether the trouble is

to improper mixture proportions, lack of adequate cooling or some defective conditions in the lubrication systems. If the motor is overheating because the mixture is too rich this can be determined by studying the character of the exhaust gases. If these have a pungent odor which not only assails the nostrils but which causes the eyes to water as well, and if black smoke is issuing from the muffler one may safely ascribe the overheating to a surplus of fuel in the mixture. Overheating is often due to carbon deposits and if these are at fault they may be removed as indicated in the preceding chapter. The only way to find out if excessive amounts of carbon are present in the combustion chamber is to remove a spark plug or valve chamber cap, and judge the amount of carbon present by inspection of the cylinder head interior. After one ascertains that the overheating is not due to poor mixture or to carbon deposits, it is necessary to inspect the various portions of the water cooling system and also the means of lubrication employed. If an engine is overheating because of lack of oil, it will pound much more than if the abnormal rise in temperature is due to failure of the water to circulate properly, or to the mixture being rich. Steam issuing from the radiator is considered a symptom of defective cooling and is stated to be an infallible indication by some authorities. The writer does not agree with this view, as any motor which is cooled properly when operating under normal conditions will often cause the water in the radiator to boil if the mixture is rich or if lubrication is poor. This does not necessarily indicate defects in the cooling system, but merely shows that the radiation is not energetic enough to absorb excessive or abnormal rise in temperature, due to some cause other than a defect in cooling.

The easiest thing to look for when one's sense of smell indicates that the trouble is not too rich a mixture is some defective condition in the water cooling system. There are two common methods of cooling in general use as outlined at Fig. 169. That shown at A is the simplest, because the water circulates by a natural principle that heated water will rise because it is lighter than cool water. The system shown is used on Overland cars and is the simplest possible method of cooling when liquids are employed for that

purpose. The heated water rising from the cylinders AAA through the cast manifold B, to the top of the radiator D. it flows through the radiator and becomes cool it return cylinder jacket through the water manifold attached to tom of the jacket. The flow of water is indicated by th black arrows, while the draught of cooling air passing thro

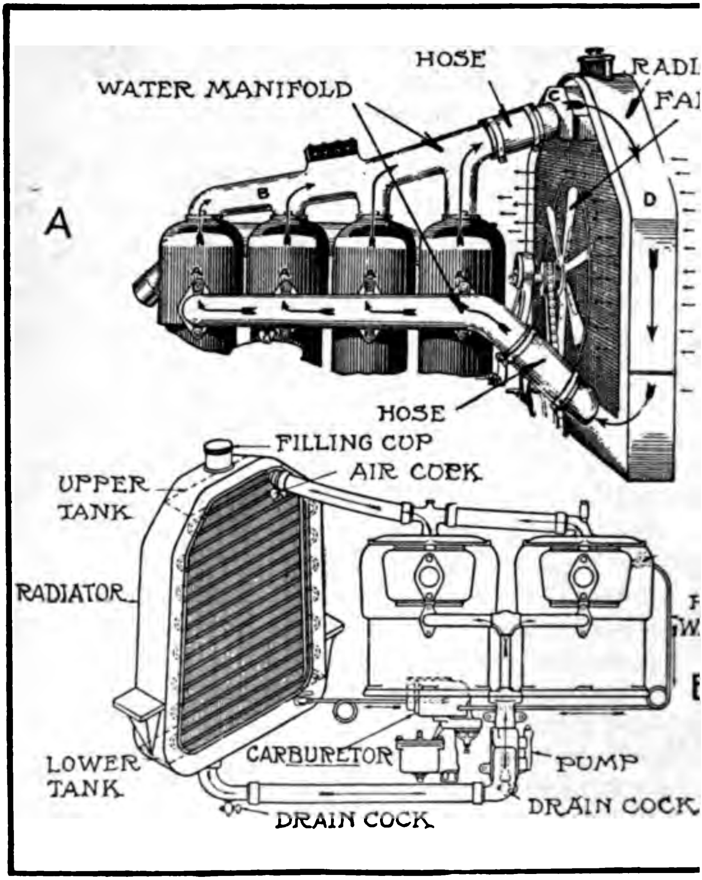


Fig. 169.—Methods of Cooling Automobile Engines Outlined. *Overland* Thermo-Syphon System. B.—Water Circulation b *Pump*.

liator is shown by lighter arrows. In order to assure passage air currents through the radiator when the car is standing still th the engine running, a power-driven suction fan is placed be-nd the radiator to draw the air through the interstices between e radiator tubes. With a simple thermo-syphon system the only ing that will interfere with proper circulation of the water is diment in the water jacket or manifold, defective rubber hose, terruption of fan drive, and constriction of radiator passages. the system of cooling shown at Figs. 169, B, and 170, a pump is pended on to promote circulation of the water, and in addition the defects previously enumerated, poor circulation will result the water pump or its driving means are at fault. The complete oling system of the Packard four cylinder car is shown at Fig. l, with all important parts clearly outlined. It will be noticed at whether the thermo-syphon or pump circulation system is used at a cooling fan driven from the engine is considered necessary.

Overland Model 82 Cooling System.—The cooling system (Fig. 9) of the Overland Model 82 is pump actuated. The pump is ated on the left hand side of the motor and driven by the gneto shaft, pumping the water from the lower part of the diator through and around the water areas of all cylinders, shown in illustration, into the top of the radiator. It is cooled its downward passage through the radiator and recirculated the pump. The rapidity of circulation of water is governed by speed of the motor. The cooling system is therefore positive l absolutely reliable in its action.

The water pump (Fig. 174) is lubricated by means of a com-sion grease cup. The pump shaft is drilled in the center so t the grease from the one cup supplies both pump bearings. s cup should be given a turn or two every four or five hun-d miles. The pump is provided with a drain cock, which uld be opened about once a week to let all water and accumulated t run out. This drain cock may be used in conjunction with drain cock on the water pump inlet elbow to drain the water the cylinders when the car is to be stored in cold weather. water pump is packed with asbestos and heavily graphited. glands are countersunk, making the packing conical in shape.

thus preventing leakage of water without undue pressui pump shaft.

After a new car has been run a thousand miles the sti nut on each side of the pump should be tightened a trifle. of the water through the radiator is aided by means o blade fan set on the front end of the motor and driven l of a "V" belt from the pump shaft. If the leather be

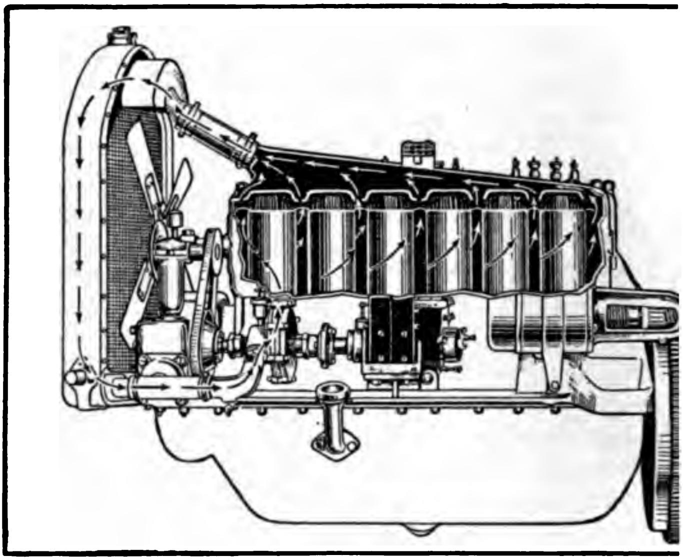
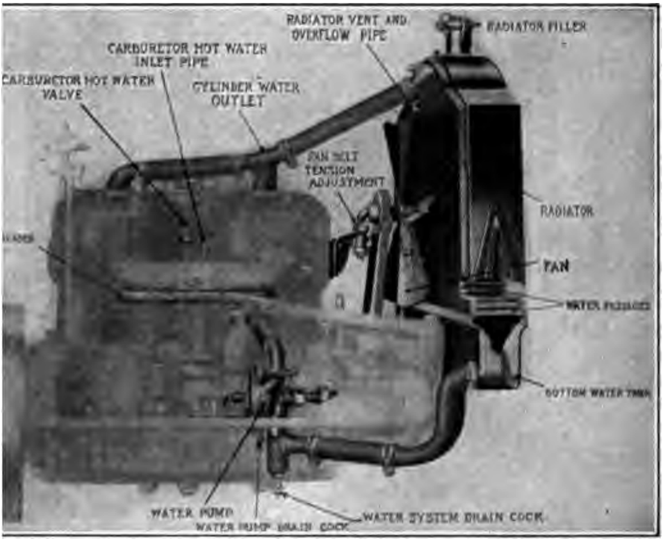


Fig. 170.—Overland Six Cylinder Engine Showing Cooling Parts.

fan stretches from considerable use, it may be tightened b ing the stud on the fan bracket and raising the fan enou move the slack from the belt.

Deposits in Radiator and Piping.—The form of radia generally used at the present time has a number of ver tortuous passages through which the water must pass from the upper compartment where it is discharged afte the motor cylinders, to the lower compartment where i after being cooled and from which it is drawn by the ci

ıe water used in some localities for cooling contains much ıer in suspension or solution which will form scale or deposit in the radiator tubes. It does not take much riously reduce the ratio of heat conduction between the er inside of the tube and the cooling air currents which



-The Packard Cooling System, Showing All Important Components.

ted about their exterior. As cylinders are generally of a certain amount of rust will be present in the water l this also may get into the radiator piping. If an anti-lution using some salt as a basis such as calcium-chloride d, after this has been circulated through the radiator ʒ for a time it may deposit solid matter in the form in the piping or radiator. Anti-freezing solutions that ·cerine may have a chemical action due to the acid some-d in the cheap commercial grades of glycerine employed ırpose. This chemical action results in the deterioration er jacket walls, and also contributes to the rust deposit.

Cleaning Sand from Water Jackets.—In some cases ex heating of an engine has been found to be due to a retent part of the sand core in the water jacket of the cylinder c This is very apt to be the case if the casting is in such that the water jacket interior is inaccessible. On those ty unit castings where a large side plate is employed to cl opening that occupies practically the entire side of a water no difficulty obtains in cleaning out all core sand, but whe precaution is not taken and the core supported by prints of size, there is considerable difficulty in clearing the casting in cases. For those not familiar with foundry practice the may say that the core is that portion which is used in the to represent the space between the cylinder wall and water j as it is necessary to use some such filler in the mold when p the molten metal into the impression left by the pattern to the cylinder. Cores are usually made of fine sand held to by binding material, and in some cases with pieces of wire ru through as a re-enforcement, the whole being baked to for piece before it is placed in the mold. A piece of this cor become lodged in some angle or corner and remain there though the greater portion of the core is removed by the fou man. This may not become loose until the engine has b use for some time, and then it may be carried into a pipe or ing and partially or wholly interrupt the water circulation. piece of core may dissolve and deposit considerable sand i water jacket which will collect in some corner where it may circulation. In order to remove all traces of sand, where m ical means are not practical, an authority recommends a so of hydrofluoric acid and water, the proportions being abo part acid to ten of water. This should be poured into the and allowed to stand over night, which will loosen the sa dissolve it. The cylinder jacket should be thoroughly draine all traces of the acid removed by flushing thoroughly wi water under pressure. Hydrofluoric acid is the only one th attack sand, and it is well to remember that it has the same on glass which is usually indifferent to the action of the common acids. Care must be taken, therefore, to keep it

special rubber container, in which it is received from the chemica supply house. While this chemical will also attack the metal c which the cylinder is composed, the diluted solution recommende will have no material effect in the short time required to thoroughl dissolve the sand.

It is not advisable to use the diluted acid in the water space of the radiator, as the brass or copper used in this part of th cooling system is much thinner than the material employed in th water jacket, and is also more easily attacked by the acid. Fo cleaning out the water spaces of a radiator a solution of potas or washing soda may be used. This will cut the rust and som forms of scale and will dissolve them or loosen them sufficientl so the deposits may be thoroughly flushed out with water or stea under pressure. The solution will work more rapidly if it i brought to the boiling point before placing it in the radiato The potash solution is also valuable in removing rust from th water jacket interior.

Incrustation is most commonly caused by carbonate of lim which is held in solution in some water as a bicarbonate; therefore when the water is heated the carbonic acid is driven off and th carbonate is precipitated in the form of a muddy deposit whic hardens in the presence of heat into a nonconducting scale in thos portions of the water jacket where the heat is greatest, and whic remains in the form of a powdery deposit in the radiator tube where the heat is not great enough to harden the sediment. Some times the deposit is sulphate of lime, this also being found in th water available in some localities. The reason that water contain so many impurities is because it is one of the best known solvents Pure water is never found in nature and can only be obtaine by a process of distillation. The purest natural water is rain and if this is collected before it touches the earth it contains onl such impurities as may be derived from the atmosphere, these con sisting of gases in the open country such as nitrogen and carbo dioxide. That falling over towns absorbs quantities of acids an soluble salts. Rain water collected near the ocean contains chlo rine. The source of water supply in many communities is som river flowing *through or within a short* distance. A large variet

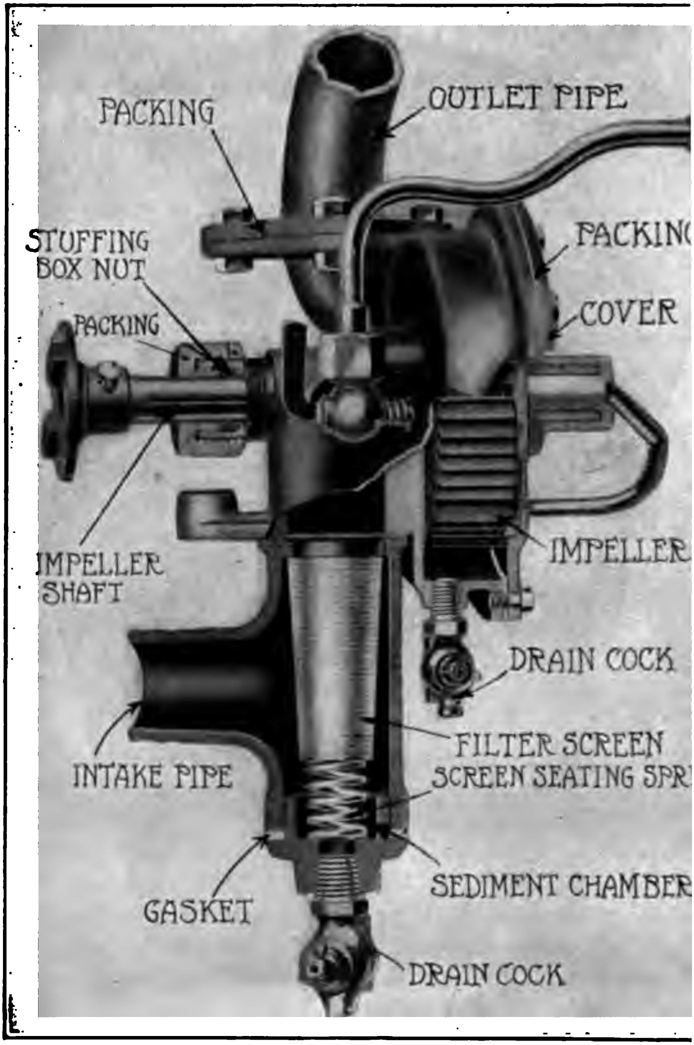


Fig. 172.—Part Sectional View of the Packard Centrifugal Wate

of substances may be found in solution in river water, the mai element being derived from the rocks through which the wat of the springs which have fed the river has percolated. The again, river water is often contaminated by the drainage of tow or of manufacturing establishments situated on the banks of th river. Spring waters also contain many salts and minerals. Wat that has been obtained from ponds is often rich in vegetable matte As it is not practical for the motorist to use distilled water fo filling the radiator and water jackets, it is apparent that th water obtained from the other sources will contain impurities i various amounts. If the water is very hard or contains muc salt, it will be well for the motorist to save rain water for use i the cooling system. The best solvent to use depends entirely upo the composition of the water, and as this varies in all portion of the world it is not possible to enumerate the best chemicals fo removing incrustation or to neutralize the material in solutio The advice of a local chemist should be sought in matters o this kind.

Deterioration of Rubber Hose.—In order to avoid fracture o the water manifolds from vibration, as would be the case if thes were attached to the radiator by nonflexible metallic connection it is customary to interpose pieces of rubber hose between th radiator and the manifolds as shown at Fig. 169, A, and wher the manifolds are the built-up form, rubber hose often forms a important item of the piping system as shown at Fig. 171. Whil it is imperative to use the best quality steam hose for this purpos even this material may depreciate in use. A certain amount of oi and grease will find its way into the cooling system, usually fro the grease cups used to lubricate the water pump bearings. Thi causes the hose to rot inside as the oil has a chemical action upo the rubber. Strips of the interior lining may become detache and may interfere with water circulation by constricting the bor of the hose. If anti-freezing solutions containing glycerine ar used, depreciation of the hose is inevitable. The best remedy i replacement of the defective hose with new, as this material is rela tively inexpensive, in fact, one may obtain special hose connection for use on all the popular makes of cars from the large automob

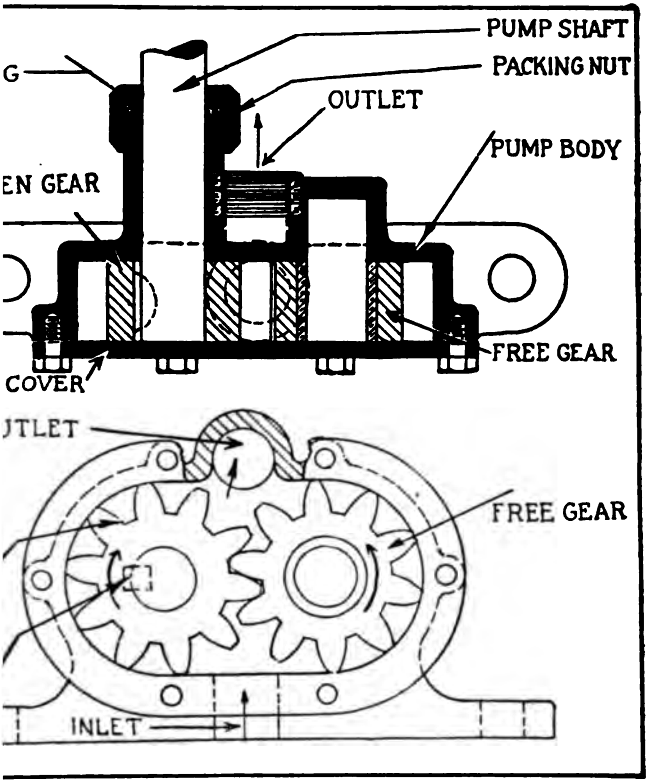
supply houses or manufacturers, these being cut the proper le
and not needing any fitting.

Pump Forms and Troubles.—In the water cooling systems wh
employ a pump to insure positive circulation of the water
may experience cooling troubles if the pump becomes inoperat
for any reason. Two forms of circulating pumps are commo
used. That shown at Fig. 172 is a centrifugal form in which
water is circulated by the rotation of a multi-bladed impeller
the casing, and the design outlined at Fig. 173 is a more posit
form in which two gears are depended on to keep the water
movement. In the centrifugal form the water enters the pu
casing at the center, and is thrown outward by the revolving
peller member, passing out of the case through an outlet pipe
tached to the casing. In the gear pump the water enters the ca
through either of two openings, and as it cannot pass directly fr
the inlet to the outlet on account of the tight fit of the gear te
and of the gears in the casing, the only way it can flow from
side of the case to the other is by filling the tooth spaces of
gears and being carried around from the intake to the disch
opening.

Any condition that would interfere with rotation of the imp
of a centrifugal pump or the gears of a gear pump will inter
with circulation because the water cannot flow by natural m
when the system is designed with a view of keeping it in mo
by the use of a pump. It is possible for the pump driving m
to fail, and in fact on many of the early model cars this w
very common trouble. At the present time water pumps are dr
by positive connections with the camshaft, and there is but l
opportunity for failure of the driving means. If a pump has
used for a long time the steel shaft on which the impeller is mou
may become rusted enough so that it will be weakened and
rupture. Sometimes the key or pin holding the impeller in p
on the shaft will shear off, this being very apt to happen if
pump becomes filled with ice, a not uncommon occurrence in
tain sections of this country during the winter season.

The continued rotation of the impeller of a centrifugal
or the gears of the gear pump may cause wear in the pump

nuch space between the impeller and the pump casing
y of the pump will be materially reduced. The only
this condition is to replace the worn parts with new.
·ifugal pump outlined at Fig. 172, which is an accu-



,—Sectional View Showing Construction of Gear Pump.

ntation of the device used to circulate water on Pack-
d six cylinder cars, it will be noticed that a filter screen
d between the intake pipe and the impeller chamber.
n of this screen is to remove all sediment from the cool-
with the object *of preventing* undue depreciation be-

tween the impeller member and the pump casing. In perf this function the screen may become clogged up, and will n mit the water to flow through it as promptly as it should. sion is made for removing the strainer, and this should be out through the opening left after the sediment plug is re and thoroughly cleaned before it is replaced.

One of the annoying conditions, though not a serious on is noticed in a water pump is leakage at various points.

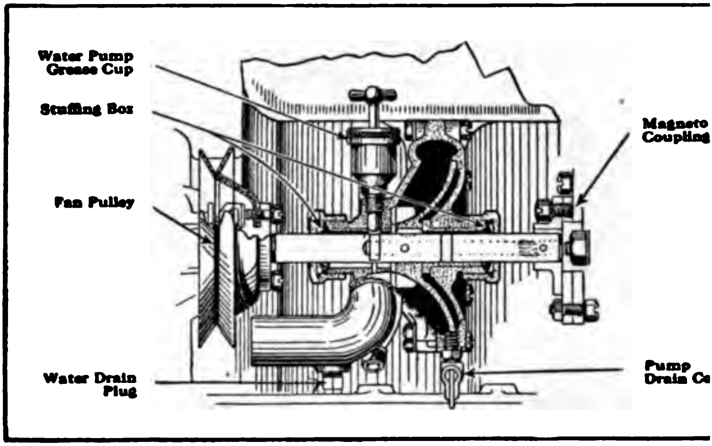


Fig. 174.—Sectional View Showing Overland Centrifugal Pu

evident that there will be an opportunity for water to around the driving shaft if the stuffing box is not kept pı screwed up. The stuffing box is provided with a flexible packing which may be compressed tightly against the sh screwing down the stuffing box nut and which forms an e seal against escape of water. The stuffing box packing ne newal from time to time in order that it may form an effecti Other points where a pump may leak are at the packings b the pump case or body and pump cover. If tightening taining screws or bolts does not stop the leaking, a new p must be made to replace the defective one. Pump packi usually of well shellacked cardboard cut to fit the pump

contour and with the screw holes punched through with a bel punch. Sometimes specially prepared rubber packings are use for this purpose.

If the pump is suspected of being defective the following point should be looked at in order: First, the driving means betwee the pump shaft and the engine; second, the retaining means fo driving the impeller of a centrifugal pump or the driven gear o the gear pump; third, the fit between the gears or impeller an the pump casing interior; fourth, the fit between the impelle shaft and its bearings; fifth, the condition of the filter screen o strainer if a member of this nature is interposed between the pum intake and interior. The plunger form of pump, which is widel used in marine service because it is self-priming and must lif water, and the eccentric rotor forms, are seldom used on auto mobiles. Practically all pumps are either of the centrifugal pat tern shown at Fig. 174 or of the gear pattern outlined at Fig. 17

Methods of Fan Belt Adjustment.—If the motor heats u when the engine is running and the car standing still, it is neces sary to inspect the fan driving means to make sure that this i functioning properly and that the fan is turning all the time th engine is running. Most fans are flat belt driven, and are mounte on some form of bracket that will permit of maintaining the fa driving belt at the proper tension to insure positive rotation o the fan blades. Some of the most common adjusting means ar outlined at Fig. 175. At A the fan is mounted on an extensio from an eccentrically mounted piece which may be turned in th clamping support to increase the distance between fan pulley an driving pulley centers. In addition to the eccentric, provision i made for keeping the fan belt at the proper degree of tension by coil spring attached to a lever fastened to the fan supportin crank at one end and to the supporting bracket at the other. A similar method is shown at B, as the fan shaft is carried at on end of a bell crank which fulcrums on a supporting member i such a way that the tension of the coil spring on the long arı of the bell crank keeps the fan belt tight. At C the fan support ing standard is of tubular form and may be raised or lowere in *the socket at its lower end.* When the proper degree of a

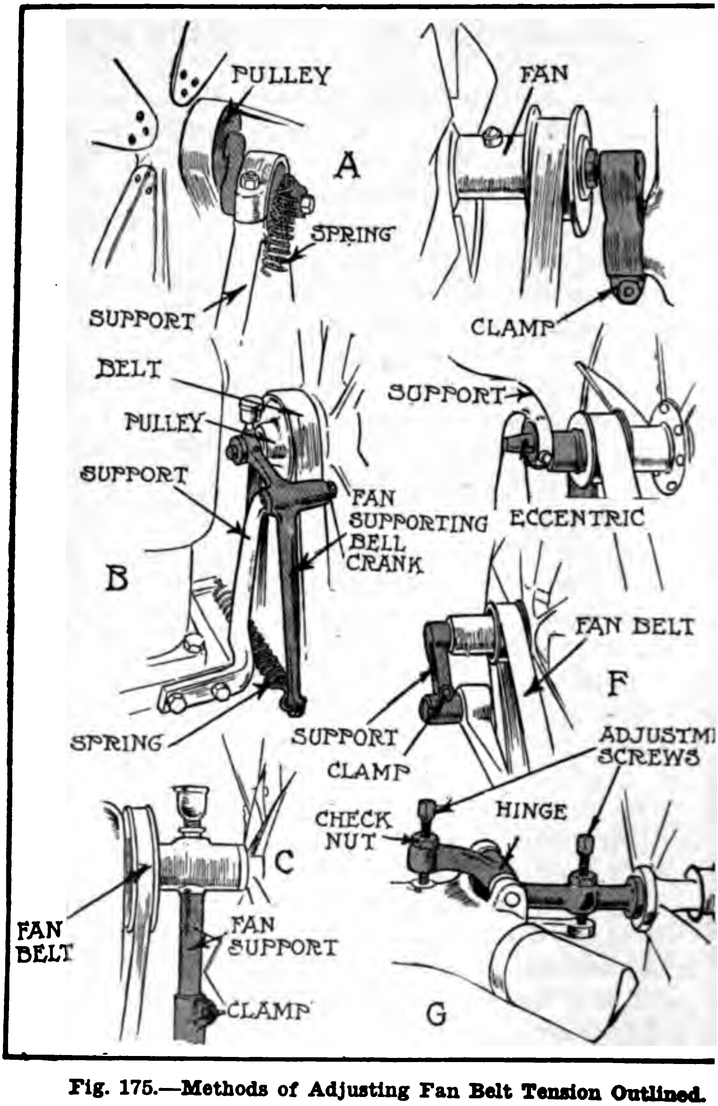


Fig. 175.—Methods of Adjusting Fan Belt Tension Outlined.

tment is secured the fan support may be firmly clamped in sition. At D the fan is carried by a simple lever which swings out a boss attached to the cylinder. In order to alter the fan lt tension the clamp nuts may be loosened and the lever swung er until the belt is properly tightened. This adjustment is re-ined by tightening the clamp nut. Another application of the centric principle is shown at E, while another form of swinging pporting lever is outlined at F. The method at G is distinctive d very accurate adjustment of the belt tension may be secured. he fan hub rotates on one end of a lever which swings on a inge formed integrally with the water manifold. Adjustment rews are provided at each side of the hinge to regulate the eight of the fan. To tighten the fan belt the adjustment screw earest the fan must be screwed down to raise the fan supporting ver, while that at the other end must be screwed out the same mount as the other is screwed in. When the proper degree of nsion is obtained the adjustment screws may be locked with itable check nuts.

Lacing Flat Fan Belts.—Lacing a fan belt is not a difficult peration, but unless care is taken in performing the work it is ot easy to obtain a joint that will be neat and enduring. Certain reliminary precautions are necessary, an important point to ob-rve being to make sure that the approximate edges of the belt e cut straight and at right angles to the longitudinal edges. The oles should be punched through with a belt punch, should be no rger than absolutely necessary, and should be distributed so as weaken the belt the least. Belts used for driving cooling fans re seldom wide enough for more than three holes. It is not al-ays possible to obtain rawhide belt lacing narrow enough to be ed with these narrow belts, but it is possible to cut strips from e wider lacings such as can be obtained from any machine shop. he cutting may be done as indicated at A, Fig. 176, it being portant that the knife have a very keen edge. The knife should held between the fingers and the palm of the hand so the thumb n be employed as a guide to maintain the strip to be cut off of gular width. The lacing to be split should be given a preliminary t of about two inches, then the knife should be placed with the

point resting on a bench, the blade being inclined slightly tc a good cutting angle. Take hold of the strip to be cut off w free hand, and by pressing the thumb firmly against the (the lacing and the bench draw the strip carefully upward. the laces are cut, trim the ends to a long, narrow point, s may be inserted in the holes punched in the belt.

In lacing a belt, first stick one lacing end through one center holes in the belt from the under side, which is the

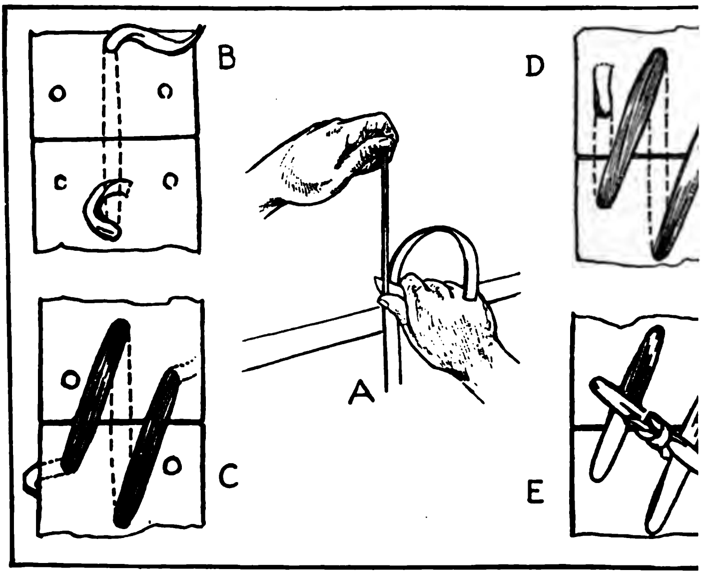


Fig. 176.—Method of Lacing Flat Fan Belt.

that will run next to the pulleys. Repeat with the other the belt lace and draw the ends of the belt together, as at B. Next place one end down through the side hole opposite end of the belt and bring it up through the hole same side of the end of the belt, as shown at C. Rep operation with the other end on the other side, as show The last step is to tie the ends of the lacing together at of the belt and cut off the surplus material. The three s

side of the belt will run parallel to each other and there o bunching to interfere with smooth running over the Metal belt lacings are sometimes used for this purpose, are not so satisfactory as the more pliable material, the small diameter of the fan pulley. While the flat type most generally used, as it is the most serviceable, section belts are sometimes employed, these running

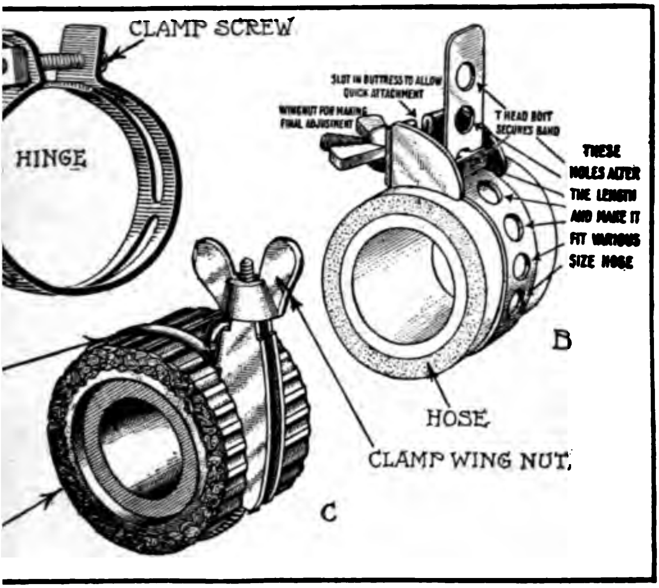


Fig. 177.—Hose Clamps of Good Design.

ed pulleys, or V belts running in 28 degrees straight d driving members.

lamps.—The problem of compressing the rubber hose tightly enough around the manifold and piping of r so they will not permit water to escape at the joint to solve unless hose clamps of good design are used to he hose in firm contact with the pipe. The simplest se clamp to have received general application is shown , A. This is made of a band of sheet metal, stamped

and bent to the form shown. A clamp screw is used to tighten the clamp around the hose. While this form is generally used it is sometimes possible to screw these up so tightly that the open ends will abut without forming a tight joint. Difficulty is sometimes experienced with this form when replacing worn hose with new in closing the ends enough to catch the nut on the end of the clamp screw. This calls for the use of a longer clamp screw than that ordinarily furnished with the clamp. Another disadvantage of the form shown at A is that it will fit but one size of hose.

The Morgan hose clamp, which is shown at B, has the advantage of being quickly attached and of being used with several different sizes without alteration. As will be noted by the illustration, it includes a flat band and buttress, and a slot in the latter permits of quick adjustment. The band is secured by a T head bolt carrying a wing nut, as indicated. The band is provided with several holes for the purpose of fitting different sized hose. The clamps come in a variety of sizes and one of the good qualities of this design is that no tools are necessary to adjust it. Another form of clamp that has the advantage of being adaptable to a number of sizes of hose and which also insures a tight joint is shown at C. The main portion of the device is a stamped buttress which has a wire clamp fastened at one end, designed to encircle the hose forming a guide in the channel section for the threaded end of the clamping wire which is guided by it and which is tightened by means of a winged nut. These clamps are much superior to the cheap form of wire hose clamp used in connection with garden hose which calls for the use of a special tool to apply it. Adjustable clamps are necessary because it is imperative to have water joints of such a nature that they may be readily broken when necessary.

Restoring Broken Water Pipe.—In attempting to remove a water manifold made of brass tubing from a motor cylinder a workman used a large wrench in endeavoring to unscrew a nut rusted in place. The wrench slipped and bent the tubing in the manner indicated at Fig. 178, A. The tube was thin and was coupled to the cylinder by a flange and nut coupling, the pipe being flared at the end to seat against a corresponding male member screwed into

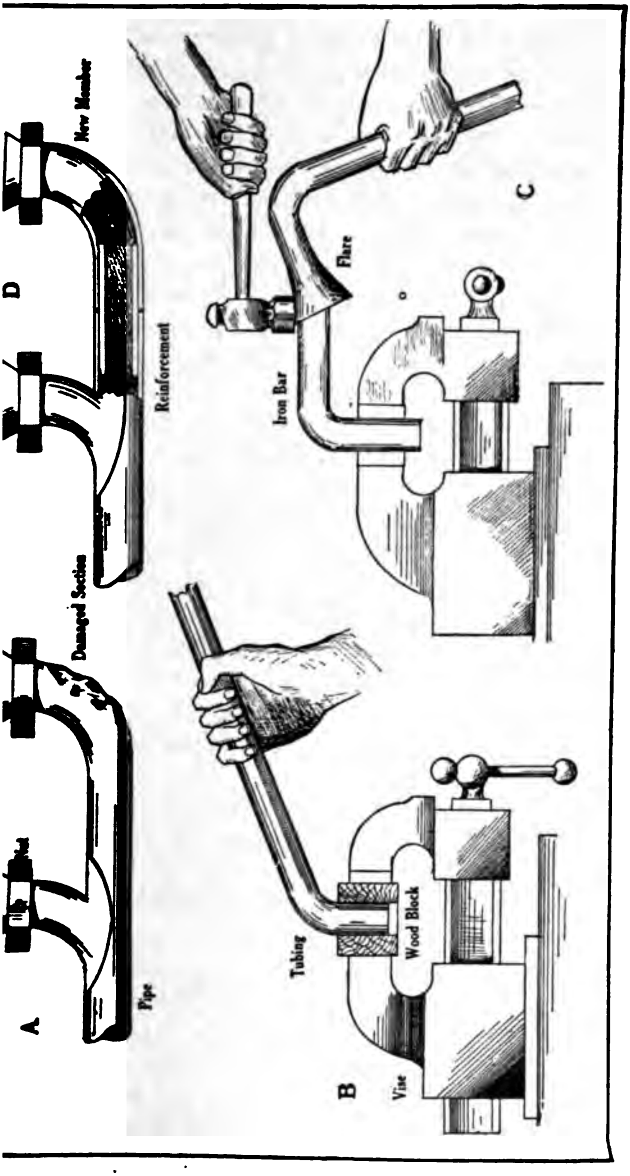


Fig. 178.—Illustrating Procedure in Repairing Damaged Water Manifold.

the water jacket, and was held in place by a nut. In a cas of this kind it is cheaper to make a new piece of pipe for the en than to attempt to straighten out the damaged section. The firs operation was to bend a piece of tubing of the required size to th proper contour to form the end of the manifold. The end o the tube was plugged with a piece of wood driven tightly in place the tube was then filled with sand. After heating the tube at th point where it was desired to bend it, it was bent to the require angle by inserting the end into a hole bored in a hardwood block held firmly in a substantial vise as indicated at B.

The next step after the sand had been removed was to forn the bell mouth or flare at the end. This was accomplished as show at C. A piece of hardwood was shaped a gradual taper and drive into the tube to expand the end slightly. A short piece of roun steel rod was bent and held in the vise and the tubing was care fully flared out by continual tapping with a hammer and keepin the tube turning so hammer blows were distributed uniforml around the end. It was necessary to anneal the end of the tub several times during the process. When formed to the prope contour it was again annealed, and while still hot was drawn int its final shape by fitting it to the nipple in the cylinder unde the pressure produced by screwing the coupling nut down tigh The concluding operation was cutting off the tubing to the de sired length as it had been left longer than necessary to facilitat handling.

In fitting the end of the tube to the manifold it was decide that a re-enforced joint would be superior to any other, and tha a neat job would be obtained if the re-enforcement was placed in side of the pipe. The end of the tube and the manifold as we were carefully squared up with a fine file till they butted togethe perfectly. A piece of brass was rolled into a tube about two inche long, the outside diameter being about the same as the interna diameter of the tubing. This was carefully cleaned and tinne and the inside of the tube was similarly treated. The parts wer heated and the tube used for re-enforcing was placed inside o the manifold and sweated into place. To make sure that it woul *not move two* small holes were drilled through and pins drive

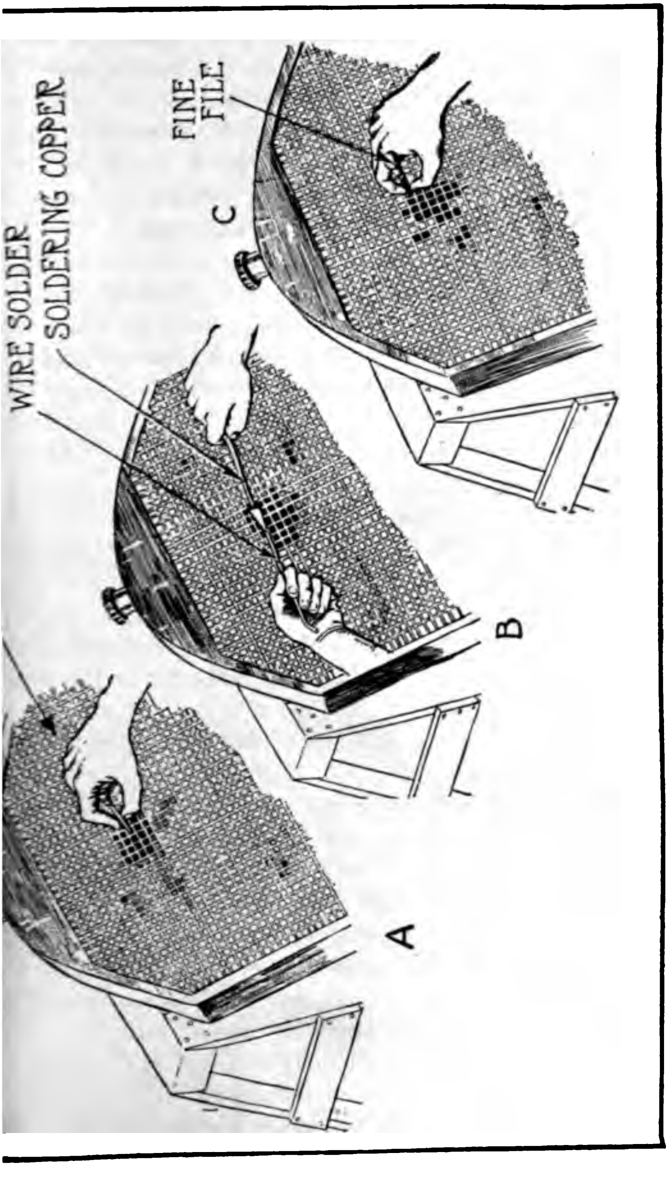


Fig. 179.—Steps in Repairing Leaky Radiator.

in to prevent movement of parts. The short bent piece of tubing was then heated up and slipped over the re-enforcement until it butted against the end of the manifold. To insure that the joints would line up the manifold was connected to the cylinder, then the entire assembly was heated and solder supplied around the joints to insure that the sweating operation would be successful. When completed, the joint had the appearance shown at D, this being a sectional view where the repair was made.

Radiator Repairs.—Radiator repairing is an operation that requires more skill than the average motorist or repairman possesses unless the leakage is at a point where it may be easily reached. It is not difficult to solder open seams or cracked joints in the upper or lower radiator tank portions, but it is extremely difficul to seal a leak in the radiator interior, especially if that membe is of the honeycomb or cellular construction. When the radiator are built, all the joints are treated at the same time by a proces of dip soldering, in which the entire section is coated with solderin flux and placed into a bath of molten solder which penetrates al joints. In attempting to make repairs in the interior of a cellula radiator by using the usual form of soldering copper, the inexper repairman is very apt to start more joints leaking, unless the iro is very carefully handled, and in many cases the radiator is wors than it was before.

A number of compounds is offered for placing in the radiato to seal leaks. These are usually of a glutinous nature and solubl in hot water, the theory being that the solution will solidify o striking the air and seal the crank. Compounds of this natur should never be used in a radiator that can be repaired by any othe means, and are a desperate last resort that the owner or repairma has recourse to in making temporary repairs.

If the leak is not a bad one, and is at a point where it ca be reached without trouble, it may be sealed as shown at Fig. 17 The first step is to empty all water out of the radiator and remov that member from the frame so it may be tilted as desired to insur that the solder will penetrate to all points of the leaky joint The first operation is to clean the metal adjacent to the leak car *fully with a very* fine file or scraper, as shown at A. After th

ng flux has been applied to all points where it is intended to older a very small soldering copper is used to melt enough rom a piece of wire solder to fill the opening. This is shown The reason the small soldering copper is recommended is e the large one holds so much heat that other joints may ted before the leaky one is properly sealed. The soldering used should have a fine point so it can penetrate into the r of the tube to some extent, if necessary. The final oper- ndicated at C is to remove the surplus metal from the sides tube with a fine file.

the leak is some way inside of the tube where it cannot be d handily, it is possible to fill that tube up with some quick iron cement and prevent the leak. This cannot be done ften, as if a number of the tubes are blocked up in this way, very probable in repairing an old radiator, the available surface will be greatly reduced, as there will be no oppor- for the air currents to pass through the sealed opening. ifest plan is to return the radiator to the manufacturer for s, as few repair shops have the skilled workmen or facilities ing work of this kind.

fects in Carburetion Group.—Troubles in the carburetor iel supply system are usually indicated by overheating of the if the mixture is too rich by misfiring or irregular opera- the fuel is not supplied in proper quantities or by loss of , even though the engine may be running regularly. There number of points in the fuel system where defects may ialize besides the carburetor. In fact, the construction of nixing devices has been refined to such a point at the present hat very little trouble is apt to exist in the carburetor. In to understand the conditions making for poor carburetion ist first study the carburetion system as a whole to see of units this is composed, then the defects apt to materialize different devices must be enumerated.

tracing carburetion troubles the first thing to do is to see iere is an adequate supply of fuel in the tank, next to make hat it reaches the carburetor. If the carburetor is provided drain cock this may be opened up, and after the opening

is cleaned out with a piece of wire the gasoline should run in a stream the full size of the drain cock nozzle bore. If liquid escapes from the drain, the fuel pipe should be dis nected from the carburetor, taking care to shut off the fuel v at the tank before this is done, and after the coupling is remo the gasoline should be turned on again to make sure that fuel feed pipe is clear. If a good stream of gasoline runs of the feed pipe one may assume that the trouble is at the buretor. If no liquid issues from the end of the feed pipe, o it drips very slowly, it is reasonable to assume that the sup pipe is clogged and this must be removed and cleaned out ei by running a fine but stiff wire through the bore or by blowing the pipes thoroughly with compressed air. The trouble may due to clogging of the strainer or filter in the fuel pipe lin well as constriction of the pipe bore.

Fuel Supply Methods, Gravity Feed.—The simplest of all supply methods is that in which the gasoline flows to the carbu by virtue of its weight or gravity. Such a system is clearly sh at Fig. 180, which represents the method of fuel supply used Ford automobiles. It is necessary that the tank or fuel reser be carried higher than the carburetor, and that it be place such relation to that member that even though the tank is n empty and the car climbing a steep hill, the gasoline will still to the carburetor. The fuel is carried in a cylindrical tank p under the front seat in this case, and is joined to the carbu by a length of flexible copper tubing. A sediment bulb is p at the bottom of the tank, this having a shut-off valve to inte the flow from the tank when desired and a sediment drain at the bottom through which foreign matter can be draine from the bulb where it collects. Water or grit is heavier the gasoline and will naturally settle at the bottom of the and as the fuel pipe is attached at the top of the bulb, one apt to have water or other foreign matter enter the carb float chamber. As an added precaution, a gauze filter is at the outlet to arrest any light particles, such as lint, which be floating in the gasoline and which would not settle to t *tom.* The flow from the tank to the carburetor float cham

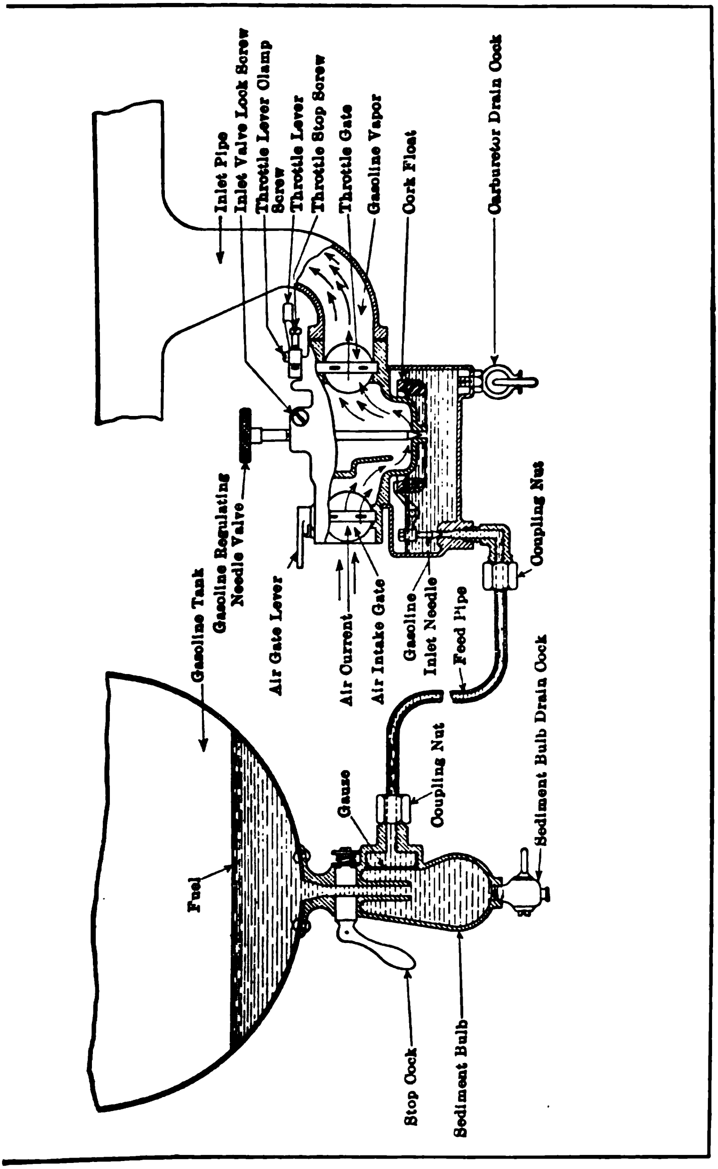


Fig. 180.—The Ford Carburetion System.

the internal construction of the carburetor itself is so clearl shown that further description is unnecessary.

Sometimes when the tank is placed under the seat and it : not possible to place the carburetor low enough to insure positiv feed at all times, the tank is arranged so that air pressure wi be pumped in to displace the liquid. A system of this natur is shown at Fig. 181, though the pressure piping is not indicate It will be noticed that the bottom of the carburetor and the botto of the fuel container are about on a line when the frame is leve If the car is ascending a gradient the carburetor will be highe

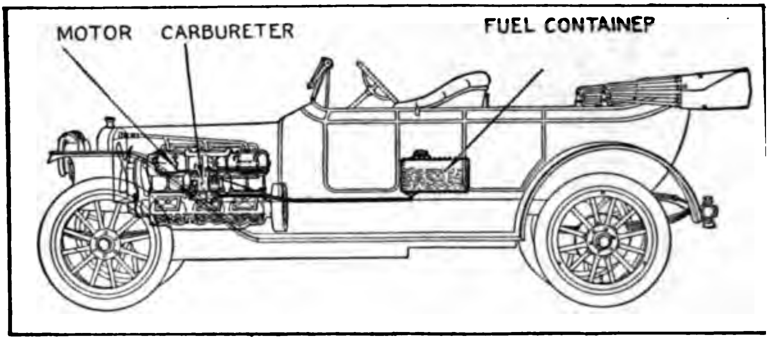


Fig. 181.—Fuel System in which Gasoline Tank is carried Under Fron Seat.

than the tank and pressure will be necessary to force the liqu through the pipe lines. Many of the 1915 cars have a gasoli tank in the cowl at the front, just back of the dashboard. Wh this tank location is used it is possible to employ the gravity fe system without placing the carburetor very low.

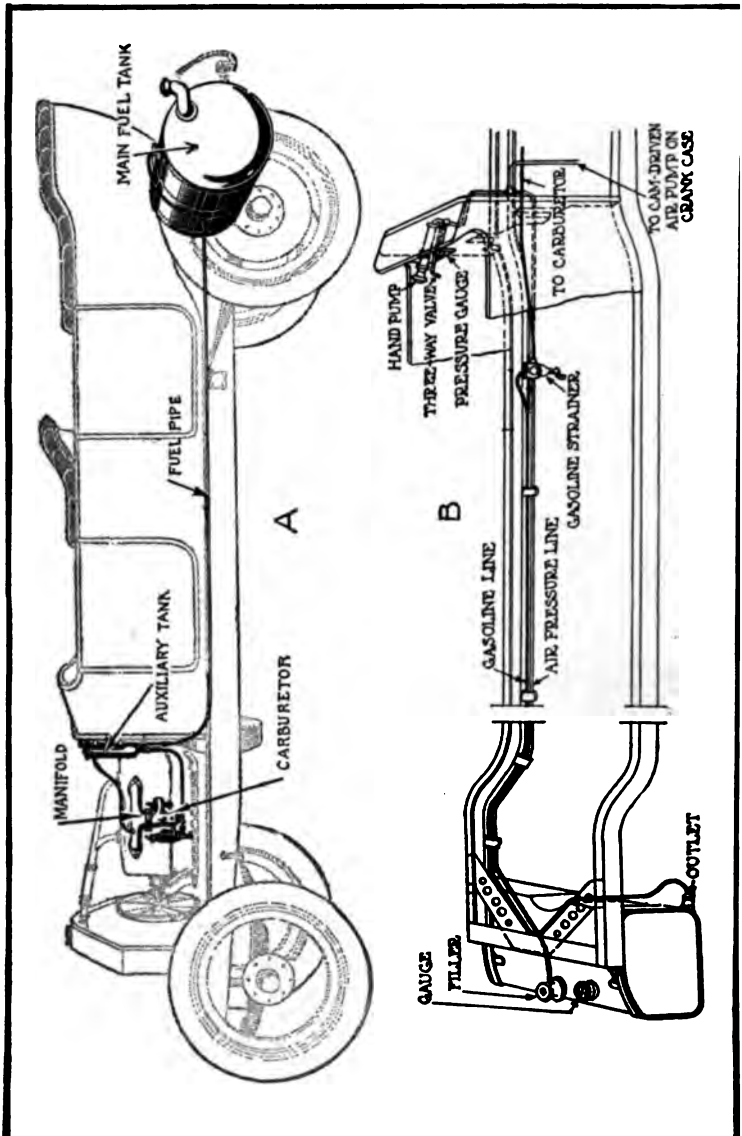
Stewart Vacuum Feed and Air Pressure Systems.—Cars ha ing power plants of large capacity or those designed for touri usually carry more fuel than can be conveniently stored in a co tank or a container of such size to be placed under the low sea now used. There are two methods of causing the gasoline flow from a tank when that member is placed below the level the carburetor. One of these, which is shown at Fig. 182, A, : volves the use of an auxiliary tank placed on the dash higl

than the carburetor, which holds a relatively small quantity of gasoline and which is supplied from the main fuel tank either by suction feed as at A, or by air displacement as at B. The system outlined at the top of the illustration has only been recently placed on the market, but is used on many of the latest cars. It is known as the Stewart vacuum gasoline feeding system and calls for the use of a special form of auxiliary tank which is shown in section at A, Fig. 184.

There are some disadvantages to the pressure feed system shown at Fig. 182, B, where the pressure in the tank is maintained to a certain point by a power air pump. If the pressure rises too high, on account of the safety valve sticking, for instance, the excess pressure is apt to cause the carburetor to flood, and even if the carburetor does not overflow, the high pressure often results in excessive consumption of gasoline. Then, again, it is important that there be sufficient pressure all the time to insure a constant supply of gasoline. If a leak starts or the garage man neglects to screw the tank filler cover down tightly after replenishing the supply, it may be impossible to get gasoline to the carburetor. In addition to a power driven pressure pump or exhaust pressure regulator, it is necessary to provide a hand pump for raising the pressure after the car has been standing for some time and the tank pressure is reduced to such a point that it will not force the fuel to the carburetor.

The best pressure system is that in which an auxiliary tank is used on the dash, a float controlled valve similar to that in the carburetor regulating the supply so that this tank always has a uniform amount of fuel therein which is not subject to pressure.

An idea of the complete piping of pressure systems in which the gasoline is fed directly from the tank to the carburetor instead of to an auxiliary tank is shown at Fig. 182, B, as applied to a touring car while the parts of a pressure system used on a roadster model in which the tanks are carried back of the front seat is shown at Fig. 183. It will be apparent that a pressure pipe runs to the top of the gasoline tank and that this is joined to a motor driven pump as well as to a hand operated plunger pump. An pressure gauge is included in the system in order to indicate


MAIN FUEL TANK
FUEL PIPE
A
AUXILIARY TANK
MANIFOLD
CARBURETOR
B
HAND PUMP
THREE-WAY VALVE
PRESSURE GAUGE
TO CARBURETOR
TO CAM-DRIVEN AIR PUMP ON CRANK CASE
GASOLINE STRAINER
GASOLINE LINE
AIR PRESSURE LINE
GAUGE
FILLER
OUTLET

if the proper amount of air pressure is available at the tank. From the tank the fuel passes through the usual form of pipe line, a separator or filter being interposed between the globe cut-off valve and the carburetor. In the system outlined pressure is also utilized to feed the oil from an oil reservoir to the engine crankcase when the proper valve is opened. Ball check valves are placed at the top of the fuel tank in most cases to retain the pressure, and, obviously, failure of this valve to seat or a leak either at the filler cap or in the pipe line will result in enough pressure loss so the fuel feed will be erratic. In event of trouble with the fuel feed one should examine the check valves in the power pump, the three-way cocks below the hand pump must be inspected, the pressure line should be examined at all joints to make sure that these are tight and pipes should be looked over along the entire length for open seams. The filler cap should also be looked at to see that it is tightly screwed down, and that it seats against a suitable gasket.

The construction of the mechanism of the Stewart-Warner vacuum system, which is contained in a tank as at A, Fig. 184, is not difficult to understand. The container is divided into two chambers, the upper one being the compartment in which the gasoline from the tank is first received, while the lower one is called the emptying chamber and supplies the carburetor. This chamber is under atmospheric pressure at all times, and the fuel flows from it by gravity only. Atmospheric pressure is maintained by a suitable vent pipe as indicated. The upper portion of the device or filling chamber is connected to the fuel tank by one pipe, and to the intake manifold by another. In order that fuel may be sucked from the main tank to the upper chamber, the suction valve must be opened and the atmospheric valve closed in which case the float is at the bottom of its travel. When the motor runs the suction of the piston draws gasoline from the main tank and supplies it to the upper chamber. When this is filled to the proper height the float rises to the top; by so doing it closes the suction valve and opens the atmospheric valve. The suction thus being interrupted, the lower chamber is filled by gravity as both chambers are now *open to the* air.

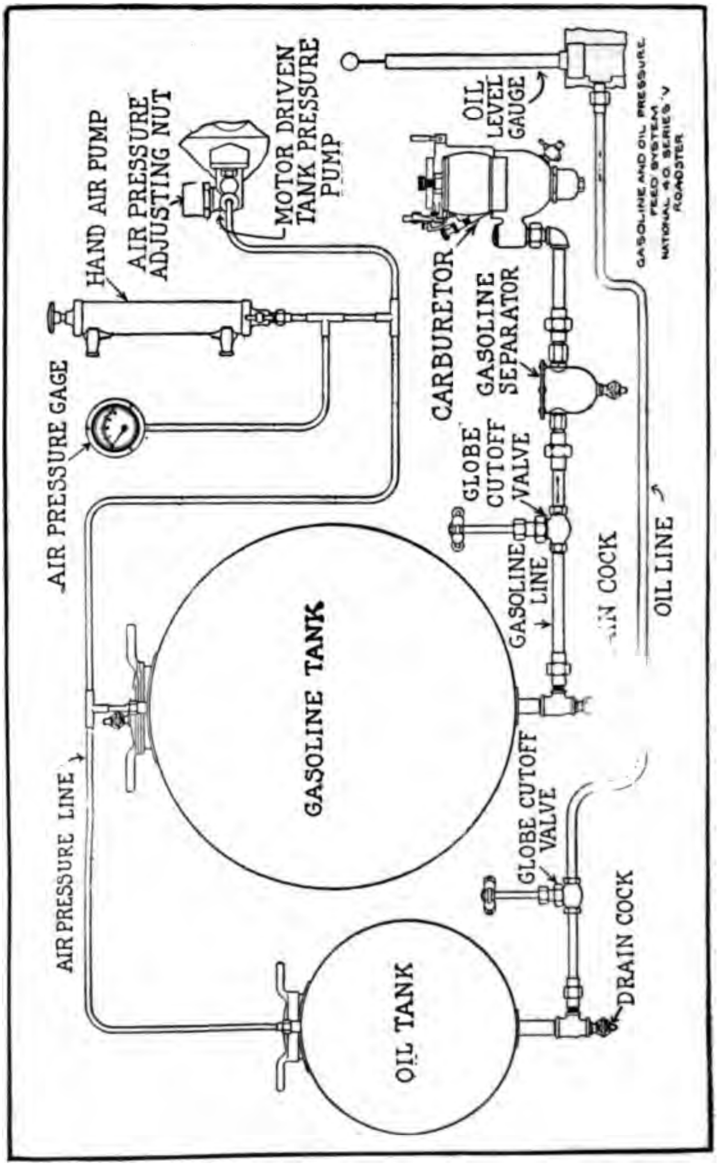
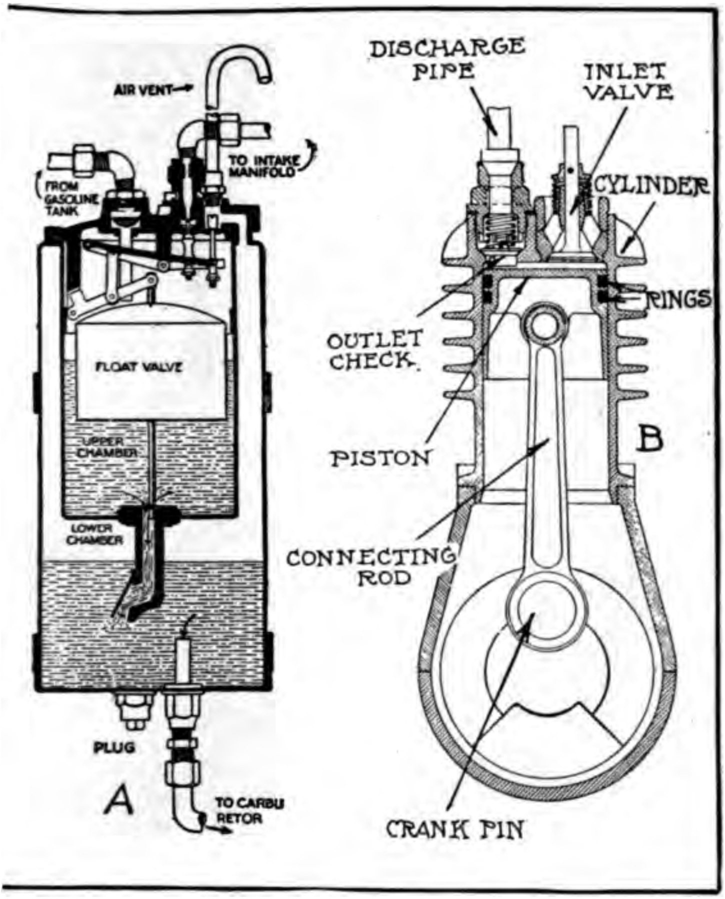


Fig. 190. The Complete Fuel and Oil Supply System of the National Roadster



184.—Two Methods of Forcing Fuel from a Tank at the Rear of the Chassis. A.—Sectional View Showing Interior Construction of Stewart Vacuum Tank. B.—Sectional View of Typical Motor Driven Air Compressor.

flap valve is placed at the lower portion of the discharge leading from the upper to the lower chamber to prevent the ine in the lower portion being sucked back into the upper It takes about two seconds *for the* chamber to become full

enough of liquid to raise the float, the amount transferr .05 gallon. The atmospheric and suction valves are act levers which are interlocked and controlled by suitable m connections with the float. Two coil springs are used so cannot assume an intermediate position; it must be eith

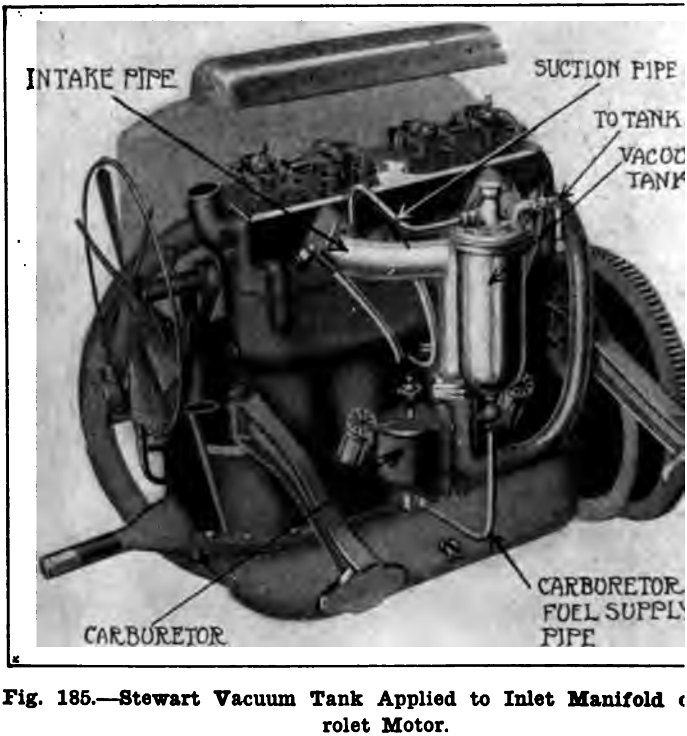


Fig. 185.—Stewart Vacuum Tank Applied to Inlet Manifold
rolet Motor.

down. The only thing that can happen that will permit the to become so low that it will not draw gasoline from tank is when the pressure is below four ounces, it being this condition can exist only when the motor is runni 600 R. P. M. with fully opened throttle. If the car is to stand long enough so the lower tank becomes emp *claimed that* a full supply will be obtained after the m

been cranked over four or five times with the throttle closed This system can be installed on any car and can be placed in a very short time without the use of any special tools. The suction pipe is tapped into the inlet manifold at a point as near to the cylinder as possible while the fuel pipe is attached to a member that runs to the bottom of the gasoline tank. A screen is provided at the end of the fuel pipe to eliminate troubles due to sediment Since the fuel is sucked from the gasoline tank the filler cap need not be airtight; on the contrary, it should be provided with a small vent so the fuel tank will be at atmospheric pressure. While the usual method of installation is as outlined at A, Fig. 182 where the device is placed on the dashboard, some makers mount it as indicated at Fig. 185. In this case it is attached to the inlet manifold, which means that short suction and fuel supply pipes to the carburetor can be used.

Air Pump Construction.—Where the fuel is lifted from the main container by air pressure, this is obtained by means of a plunger pump in most cases, though sometimes a portion of the exhaust gas is by-passed from the exhaust manifold to the tank through a special form of pressure reducing valve. The construction of a typical air pump that may be used for furnishing air pressure, and that is adapted for placing at any convenient part of the power plant, is shown at Fig. 184, B. In essentials it is not unlike a small gasoline engine. A piston having two packing rings reciprocates in the cylinder which is provided with radiating flanges to assist in cooling. A connecting rod joins the piston to a crank pin in the conventional manner. The pump cylinder head is provided with two valves, one which opens in when the piston goes down to admit a charge of air and which closes as soon as the air pressure inside of the cylinder is equal to that of the atmosphere and is termed the inlet valve. This is carried in a readily removable cage which screws into the cylinder head. The other valve, which is called the outlet check, has an opposite taper to that of the inlet valve, and as a result tends to seat tighter on the suction stroke of pump. On the compression stroke, however, when the air pressure is sufficiently high to overcome the spring resistance this valve will *open and permit the* air to flow to the fu

tank. The troubles with a pump of this kind outside of those natural wear of the piston, rings and cylinder wall, are inv valve faults. If the inlet valve does not seat tightly, a of the compressed air will escape back through that memb the inlet valve and does not op cylinder will r ceive enough ai the exhaust che not seat positiv pump will not p any pressur trouble may be enced due to l from the fuel t in some cas pump outlet cl supposed to ret air pressure i main container.

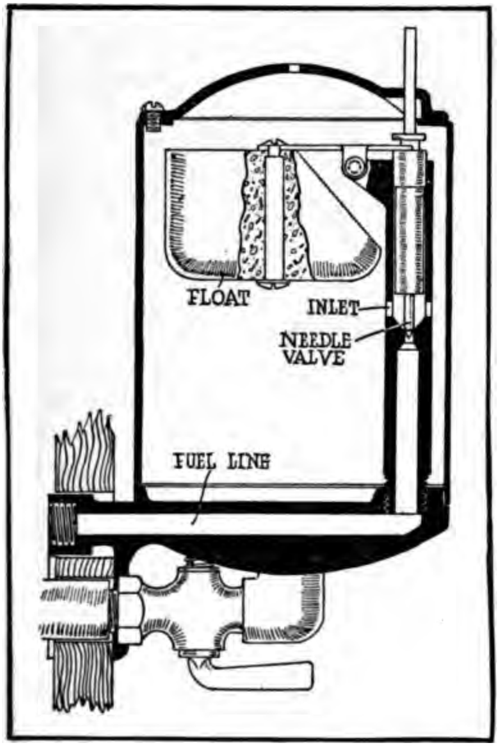
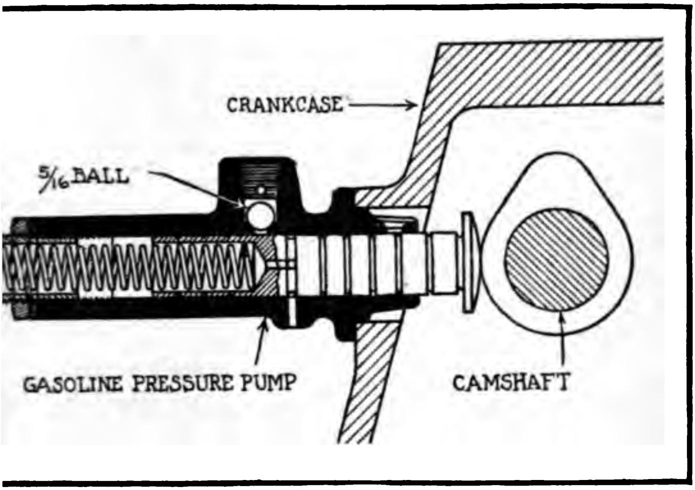


Fig. 186.—Sectional View of Small Auxiliary Tank Placed on Dash and Sometimes Used with Gasoline Pressure Feed System.

Auxiliary tan used with the p feed system, wl is desired to eli the danger of carburetion due cessive fuel fe sulting from to pressure in the The internal co tion of a typic iliary tank is at Fig. 186. A valve admits the gasoline according to the position of th When this auxiliary tank is empty the float falls and rai needle valve from its seat. This permits fuel to flow into tl *from the fuel line.* As soon as the proper level is reach

es and seats the needle valve. An auxiliary tank of this is subjected to the same troubles as the float bowl of a :or is, for the most part, these are flooding due to improper of the needle valve, or the float becoming soggy or fuel and troubles apt to result from deposit of sediment that ɜrfere with proper fuel flow. This auxiliary tank is in ›mmunication with the float chamber of the carbureter. The m the small tank is by gravity as in the Stewart system.



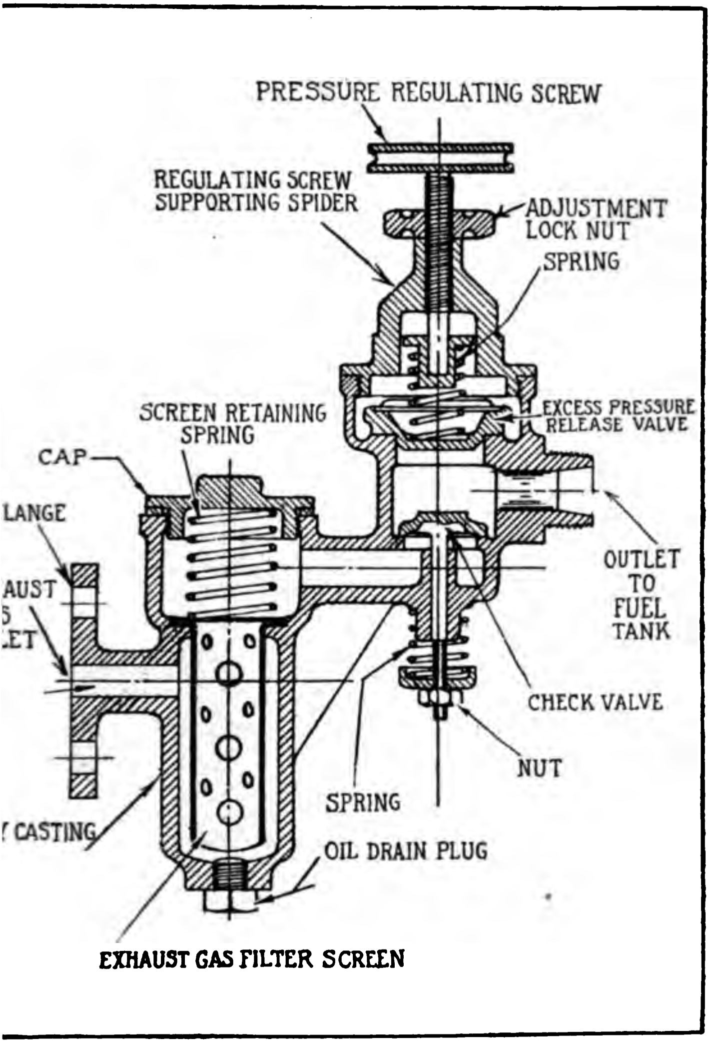
'.—Air Pump for Producing Fuel Flow on Jeffery Four Cylinder Car.

ther form of gasoline tank pressure pump of simple design the Jeffery automobiles is shown at Fig. 187. This is lo- ı the side of the crank case and is intended to be worked of the valve lifting cams. The plunger is kept pressed the cam by a coil spring. When in the position shown an t in the pump cylinder communicates with the interior by ›f an annulus machined around the pump plunger and a drilled in the plunger to communicate with the annulus. he pump plunger reaches the other end of its stroke, which mined by the height of the cam profile, communication is

made from the cylinder interior by the annulus which now registers with a discharge check of the ball form through which the pressure is delivered to the fuel container. It will be noticed that the pump plunger is provided with a number of grooves which are intended to act as packing members when filled with lubricating oil. These grooves also tend to reduce wear between the plunger and walls by insuring positive lubricity.

Exhaust Gas Pressure Regulator.—While the designs of regulating valves for application to the exhaust manifold vary, that shown at Fig. 188 may be considered a good example of conventional construction. The pressure of the exhaust gas when it issues from the cylinder is too great to permit it to be passed directly to the fuel tank. Besides, it has considerable heat and must be cooled to avoid danger of fire. The exhaust gas enters through a suitable inlet in the body of the device which is bolted to the manifold by a retaining flange. Before passing by the check valve it must first flow through an exhaust gas filter screen which not only is intended to reduce the temperature of the gas but also to prevent particles of carbon or oil passing from the body casting to the check valve portion. The exhaust gas pressure is reduced by allowing a certain portion of it to escape to the outer air through the excess pressure release valve which is kept seated by a coil spring. The pressure of this spring may be altered as desired by screwing the pressure regulating screw in or out. If the screw is turned down the spring is compressed and the gas pressure in the fuel tank will be increased because not so much of the gas will by-pass to the air. If the spring pressure is lessened, the tank pressure becomes less in proportion. The check valve is to keep the pressure in the tank from flowing back into the exhaust manifold.

When a device of this nature fails to function properly one may assume that the trouble is due to a clogged exhaust gas filter screen which does not permit the gas to pass through it, if the trouble is not due to poor seating of the excess pressure release valve or check valve. A certain portion of oil will pass through with the gas despite the filter screen and this may coagulate around the valve seats, either keeping them from seating properly and allowing leakage or by retarding their action due to the sti



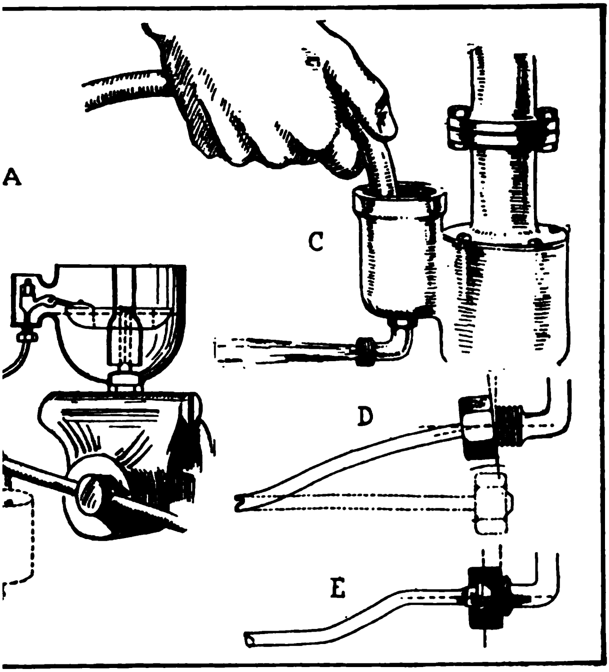
88.—Exhaust Gas Pressure Regulating Valve of Conventional Form.

material or gum between the valve and seating. The first thing to look at is the condition of the exhaust gas filter screen. This may be readily removed by unscrewing a cap and lifting out the screen retaining spring. The drain plug is then removed from the bottom of the body casting and all the sediment washed out with gasoline. The check valve and relief valve must also be cleaned out and, if necessary, reground to a proper seating. If the carburetor float chamber overflows, due to excess pressure in the fuel tank, the pressure regulating screw should be turned back or out in order that the release valve will allow more gas to escape to the air, this having the effect of reducing the tank pressure. If the tank pressure is too low, the pressure regulating screw should be turned down to tighten the spring.

Carburetor Troubles.—There are two parts to the usual float feed carburetor and either of these is apt to cause trouble. In the float chamber any defective condition that will prevent the float control valve from seating properly will result in flooding which will be evidenced by a rich mixture. If the passage the valve controls becomes clogged up then there will not be sufficient liquid in the float chamber and the engine will misfire on account of the deficiency in the fuel supply. If the float needle valve is adjusted in such a way that it will close too soon the mixture will be deprived of gasoline on account of the level being too low in the float chamber. About the only trouble that can materialize in a mixing chamber is clogging of the spray nozzle with dirt or water and failure of the auxiliary air valve to open properly. If the spray nozzle is constricted, not enough gasoline will enter the mixture. If the auxiliary air valve opens too much an excessive amount of air will be admitted in proportion to the gasoline, whereas if the valve does not open enough the mixture will be rich.

How to Test Fuel Level.—After a carburetor has been in use for some time, wear may exist at the point of the needle valve or at the needle valve seat, or there may be some depreciation in the fulcrum joint of the lever connecting the float with the needle valve. A good way of testing the float level is shown at Fig. 189, A. The float chamber of the vaporizer is held in a vise and gasoline is allowed to flow from a small can which is joined to the fuel inlet

› of rubber tubing. The gasoline will flow from this ›at bowl and raise the float as the chamber fills. The ısoline should be just a little below the top of the the mixing chamber. If the level is too high, this ced by a liquid overflowing at the standpipe, if it



ining Method of Testing Carburetor Float Level, Clearing ›d Fuel Inlet and Showing Proper Way of Connecting ›ipes.

ı condition may be easily ascertained by inspecting liquid in the jet. If one suspects that the jet is .t the gasoline feed connection on the float bowl is dirt it is a simple matter to clean the passages out ıpressed air hose as shown at Fig. 189, C.

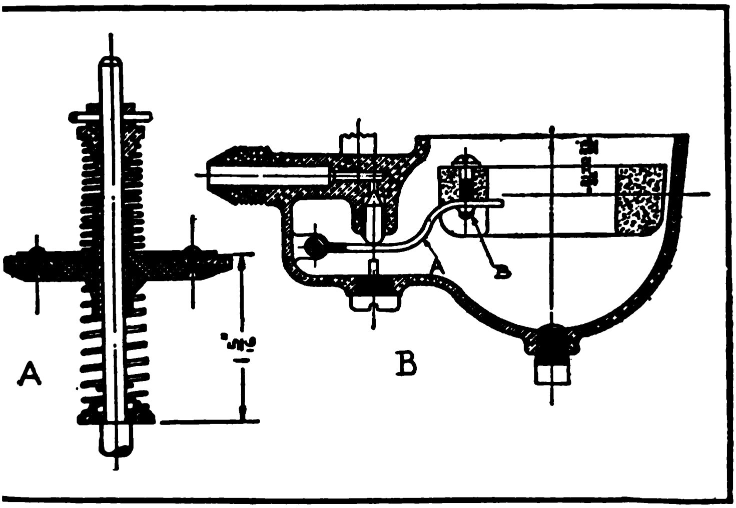
nozzle of most carburetors may be unscrewed and

removed for cleaning though this will not be necessary if the compressed air is utilized as shown. The repairman or motorist often finds it necessary to remove the fuel feed pipe from the carburetor and it is often noticed that after this is replaced a slow leak will develop around the joint. It is not difficult to connect the coupling if this is properly done, but it is important that the nut of the coupling is started evenly on the threads of the joints. The nut is often tightened when it is cross threaded and sometimes, even when successfully started it must be screwed all of the way home with a wrench due to cramping of the pipe. The right and wrong ways of connecting a feed pipe are shown at Fig. 189, D and E, the former indicating what to avoid while the latter shows the correct method. The illustration D, shows why the novice often fails to make a proper connection and succeeds only in marring the first two or three threads of the joints. The lower illustration E, shows the joint properly made. The secret is to secure proper alignment of the components before making a connection. If after having properly aligned the parts and screwed the nut fairly tight, the joint should leak slightly, do not exert undue strain on the union in an endeavor to make a tight connection, but loosen it and apply common yellow laundry soap to the threads and screw it back in place.

If a pipe is a short one and there are two couplings, it is well to loosen both unions and start the nuts at each end at the same time, screwing them down together. In this way a tube bent in several places, which tends to shorten it, may be straightened without straining any of the threads on the joints and besides it is always easier to center a loose pipe and start the nut correctly on the thread than to try and line up a pipe fastened rigidly at one end.

It is not always necessary to gauge the distance between the top of the spray nozzle and the fuel it contains in order to determine if the float level is at the correct point. With a 1914 Cadillac carburetor, the level of the fuel is tested by removing the bowl or float chamber from the carburetor, taking out the spraying nozzle and attaching the bowl to the fuel supply pipe. When the *chamber is held in* a perfectly level position the distance from the

of the float bowl to the gasoline should be from .6562 inch to 7 inch. If less than the first named distance, correction may ıade by bending down the arm A, shown at Fig. 190, B, slightly. ıe float has to be removed, shellac the screw at B, to prevent orking loose when replaced. It is sometimes necessary to d the float controlling needle valve to a new seat. This may



. 190.—How to Set the Automatic Air Valve and Float Lever in 1914 Cadillac Models.

ısily accomplished by using a very fine abrasive, such as grind- e dust.

Vith many carburetors an auxiliary air valve is utilized, its tion being to open as the motor speeds up to supply more air ıe mixture. The suggestion for testing the air valve of the llac carburetor illustrated at Fig. 190, A, is as follows: Re- the small cover over the air valve by taking out two small vs retaining it to the body of the carburetor. Next, take out mall split pin near the top of the air valve stem and remove atter complete with stem from the adjusting nut. Hold the alve as *indicated in the sketch* and measure the distance from

the leather face of the air valve to the underside of the co
the air valve stem, which should be about $1\frac{5}{16}$ inches. If t
tance is more than this it shows that the air valve spring i
and a new one should be substituted.

Relative to the position of the float it is sometimes p
that too high a level of fuel is due to the float being heavy,

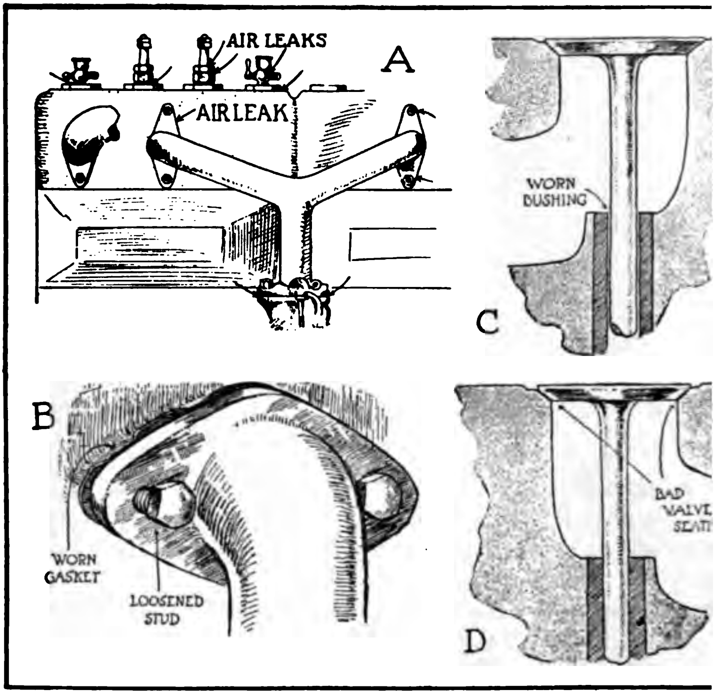


Fig. 191.—Showing Points in Carburetion System where Air May In and Cause Faulty Carburetion.

results when it absorbs a certain amount of fuel. This, of
applies only to cork floats. Before bending the arm to whi
float is attached, remove that member and dry it thoroughly.
give it one or two coats of shellac. In some types of carbu
it is possible to alter the level by adjusting the float and to

tain when this is correct by comparing the level in the glass fl
bowl with a line etched on the float bowl wall.

Influence of Air Leaks.—If any difficulty is experienced throttling down, that is to say, if it is impossible to have the mo run steady with the throttle closed without using a rich mixtı one may assume that the trouble is due to air leaks which dil the mixture. There are a number of points about a motor wh the leakage may be manifested. The main points are indicated Fig. 191, A. Air may enter through leaky gaskets either wh the carburetor fastens to the manifold or where the manifold taches to the cylinder casting. Leaks at these points are hard detect as they only occur when the piston is going down in cylinder to suck in a charge of gas. Air leaks may also be pres around the compression relief or priming cocks where they scı into the cylinder, at the valve chamber cap threads or around spigot joint of the release cock. Leaks are also apt to materia around the spark plugs where these screw into the cylinder or cause of defective packing in the spark plug body itself. Le at this point will be clearly evidenced by oil deposits around leaky portions or if the leak is serious by a hissing noise. Un these conditions it will be evident that unless that carburetor adjusted to supply additional fuel to compensate for the air le ing in that the motor will run irregularly and that it will o run evenly when speeded up so that the suction draws in the quired amount of gasoline. If the mixture is set rich at low sp to compensate for the air leaks, it will be too rich at high spee

The air leak may be around a defective gasket as shown at F 191, B, or due to a loosened retaining screw which permits manifold flange to spring away from the cylinder to some ext or the leak may result from a defective inlet valve stem guide bu ing as shown at C. If the exhaust valves do not seat properly, indicated at E, a certain amount of burnt mixture will be dra in from the manifold which will mix with the fresh gas and dil it just as air would. Air leaks may be easily tested by squirt oil or soapy water around the points suspected of being at fa If any leaks exist they will be noted by bubbles in the liquid. there is a leak *on the suction stroke* the liquid will be drawn int

crevice while the leak will show on the compression stroke blowing the liquid away from the crack because of the escaping a

In cleaning a badly sooted spark plug it is sometimes necessa to dismantle it. In reassembling, one may fail to screw down t packing gland tight enough against the shoulder of the porcel to have that member gas tight. If the leak is around a thread member such as a petcock or valve chamber cap the faulty pi

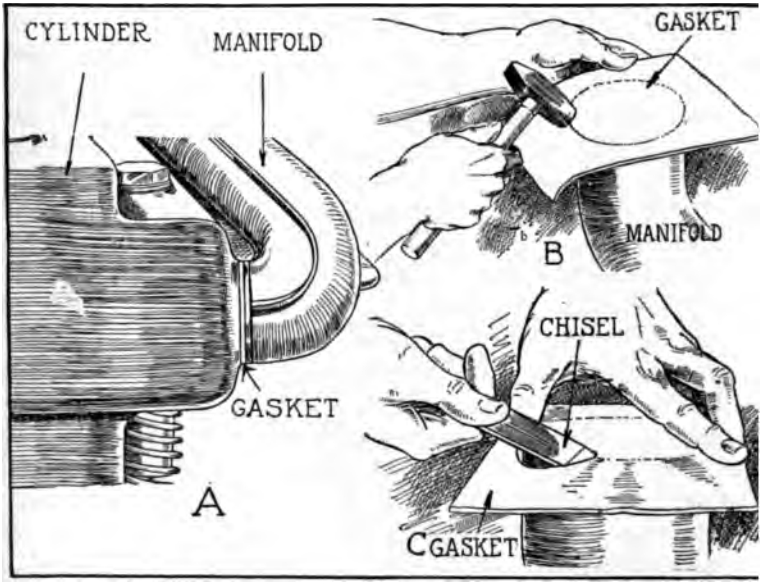


Fig. 192.—Method of Cutting Inlet Manifold Gasket.

should be removed and the threads coated with graphite pipe c pound and replaced. If the gaskets or packing members are fault, it is a simple matter to replace them. The air leaks sometimes due to blow holes in a cast aluminum manifold or leaky joints in a brazed, built-up tubular manifold. The only v they can be detected when in these members is by painstak search with oil or soapy water as previously outlined for test petcocks and valve chamber caps.

Cutting a gasket is not a difficult operation if this is to

ade of some sheet packing, such as asbestos or rubber. The ethods outlined at Fig. 192 for marking out and cutting a gasket r using the manifold itself as a guide, are those generally em- oyed by automobile repairmen. The usual location of a gasket tween the cylinder casting and manifold is as shown at A. At , the method of tamping out the shape of the gasket is clearly itlined, though better results are obtained by using a ball peen immer instead of the form shown. After the gasket has been arked out, if the material permits, such as can be done with the ibber packings used under water manifold flanges, it may be easily it to shape by using a sharp chisel in the manner indicated at C.

Notes on Carburetor Adjustment.—The modern float feed car- iretor is a delicate and nicely balanced appliance that requires certain amount of attention and care in order to obtain the best sults. The adjustments can only be made by one possessing an telligent knowledge of carburetor construction and must never made unless the reason for changing the old adjustment is derstood. Before taking up the adjustment of the leading forms carburetors, a few hints regarding the quality to be obtained the mixture should be given some consideration, as if these are operly understood this knowledge will prove of great assistance adjusting the vaporizer to give a good working proportion of el and air. There is some question regarding the best mixture oportions and it is estimated that gas will be explosive in which proportions of fuel vapor and air will vary from one part of former to a wide range included between four and eighteen rts of the latter. A one to four mixture is much too rich, while one in eighteen is much too lean to provide positive ignition.

A rich mixture should be avoided because the excessive fuel ed will deposit carbon and will soot the cylinder walls, combus- n chamber interior, piston top and valves and also tend to over- at the motor. A rich mixture will also seriously interfere with xible control of the engine, as it will choke up on low throttle d only run well on open throttle when the full amount of gas needed. A rich mixture may be quickly discovered by black oke issuing from the muffler, the exhaust gas having a very ngent odor. If the mixture contains a surplus of air there will

be popping sounds in the carburetor, which is commonly ter blowing back. To adjust a carburetor is not a difficult ma when the purpose of the various control members is underst The first thing to do in adjusting a carburetor is to start motor and to retard the sparking lever so the motor will run slo leaving the throttle about half open. In order to ascertain if mixture is too rich cut down the gasoline flow gradually by scr ing down the needle valve until the motor commences to run regularly or misfire. Close the needle valves as far as po without having the engine come to a stop and after having f the minimum amount of fuel gradually unscrew the adjusting until you arrive at the point where the engine develops its est speed. When this adjustment is secured the lock nut is sc in place so the needle valve will keep the adjustment. The point to look out for is regulation of the auxiliary air supp those types of carburetors where an adjustable air valve is vided. This is done by advancing the spark lever and openi throttle. The air valve is first opened or the spring tensi duced to a point where the engine misfires or pops back i carburetor. When the point of maximum air supply the will run on is thus determined, the air valve spring may be ened by screwing in on the regulating screw until the p reached where an appreciable speeding up of the engine is no If both fuel and air valves are set right, it will be possible to erate the engine speed uniformly without interfering with larity of engine operation by moving the throttle lever or erator pedal from its closed to its wide open position, this b done with the spark lever advanced. All types of carburetors not have the same means of adjustment, in fact, some adjust o with the gasoline regulating lever while in others the mixture p portions may be varied only by adjustment of the quantity entering air. We will now consider the construction and adj ment of various makes of carburetors that have received gen application and that may be considered as standard forms.

Browne.—At Fig. 193, a novel carburetor of recent devel ment is shown in which no adjusting means are provided an *is said that* one size of carburetor will serve all motors, the c

being that of the effective auxiliary valve opening which ·ed for different motor sizes by the use of a specially con- d bushing placed above the valve. It is claimed for this that it feeds a fuel and air mixture of constant ratio regard- speed or load.

Browne is a single-nozzle carburetor with a conventional ·rangement on one side to which the fuel is fed and from

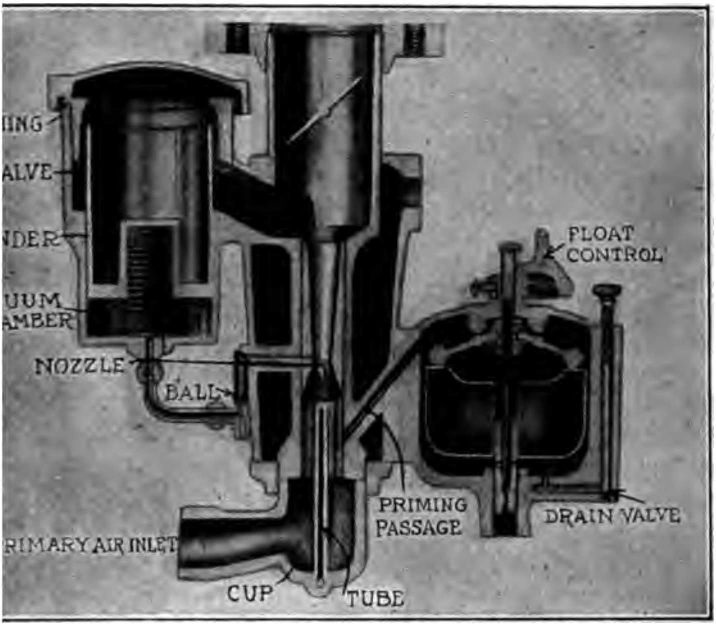


Fig. 193.—Sectional View of the Browne Carburetor.

gasoline is run to a nozzle located in the throat of a venturi e. The air valve is on the opposite side of the mixing cham- d in this construction it differs radically from other types of etors. In action the single nozzle with a 7-degree discharge)-degree approach feeds the fuel and a primary air inlet nding this nozzle feeds the air. In addition, the auxiliary ve acted upon, *it is claimed,* both by the vacuum created

by engine suction and velocity of air past the fuel nozzle, additional air in the proper proportion to the speed and loa gardless of barometric conditions

As shown in illustration Fig. 193, the auxiliary air val located in a chamber which is in communication with the ve Underneath the valve is a spring by means of which valve r is obtained. Above the valve is a bushing with a curved su and as the valve opens or goes downward the valve openi increased. A cover is provided for the valve chamber. Sinc passage from the valve chamber to the venturi ends at a poi line with the nozzle, any vacuum tending to cause fuel flow will act through the passage on the auxiliary air valve, thus ing it against spring tension. As the vacuum increases the goes downward, the opening at the top becomes greater and air is allowed to flow between the bushing and the valve. the vacuum in the small chamber underneath the valve deter the extent of valve opening, and since for a given vacuum is a definite fuel flow, for each rate of fuel flow there is a de valve position.

In order to prevent fluttering of the valve and an exces rich mixture directly after throttle closing, a ball is placed i passage leading to the vacuum chamber. This ball is ma bronze and is slightly raised from its seat. When the air is being depressed the ball offers no resistance, but when the starts to close a resistance is interposed, which prevents flutt Also, when the air valve is closed suddenly, due to throttle cl there is a tendency for the nozzle to feed too much fuel, d inertia of the gasoline. It is said that the ball retards the ment upward of the air valve in the same proportion as the flow is continued, thus maintaining a constant mixture durin period of throttle closing. In order to prevent any dirt g between the valve and the cylinder there is produced, by me the passage at the right of the air valve, a vacuum equal to on the fuel nozzle. This vacuum keeps the joint effectively cl all possible obstruction, it is claimed.

The priming lever shown, when pulled, depresses the fl *the usual* way. This floods the float chamber, but when th

reaches a certain point it overflows through the duct shown, whic leads to a cuplike portion in the primary air intake. The fuel drawn from this cup through the vertical tube shown into th venturi, where it is sprayed by the entering air, which is at hig velocity. Another feature of the Browne is the float chambe drain, which is in the form of a needle valve. This makes a simpl construction and one quite as effective and more accessible tha some of the underneath control cock arrangements.

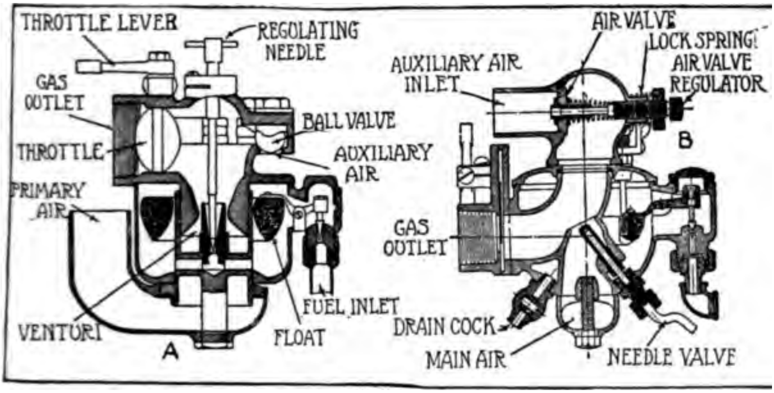


Fig. 194.—American Carburetor Designs that Have Received Wide Application. A.—Kingston. B.—The Schebler Model E.

Kingston.—The Kingston carburetor shown at Fig. 194, A, of the pattern having adjustment only by fuel regulating needl valve. This is located at the top of the carburetor and screws dow into the spray nozzle to vary the size of the opening providin communication between the interior of the jet and the float chan ber. The auxiliary air supply is admitted by a series of ball valve of different sizes, these lifting according to the degree of suctio to admit more air progressively as the butterfly throttle valve opened and the motor suction becomes greater. This carburetc is a very easy one to adjust as the mixture proportions are altere by a regulating needle. The float is of cork and controls the sma needle valve through a simple lever of the first class.

Schebler, Model E.—*This is a* very popular form of carburet

and has been very widely applied, especially in marine service. It was used on many of the early forms of automobiles but has been displaced by improved forms. The amount of fuel drawn into the mixture is altered by a needle valve located at the bottom of the carburetor and which regulates the size of the spraying orifice. The auxiliary air supply is controlled by a leather valve which is kept seated by a coil spring having a tension regulating screw to limit the valve opening. As the tension of the spring is increased, the valve opens less owing to the augmented resistance of the spring. When the spring tension is reduced the air valve will open wider and allow more auxiliary air to flow into the mixture. It will be noted in both of the carburetors shown at Fig. 194, that the primary or main air opening is not variable. This is set to certain proportions determined by experiment when designing the carburetor.

Overland-Schebler.—The device outlined at Fig. 195, is one of the most recent developments of the Schebler carburetor and is the form used on some models of Overland cars. The internal construction is clearly shown at A in the sectional view, while the external parts are plainly outlined at B. The instructions for regulating this carburetor are as follows: First, seat the needle valve, which is indicated as A in the sectional view, by turning the adjusting screw to the right until it stops. Do not use pressure on the screw after it meets with resistance. Then turn it to the left about a turn and a half and prime or flood the carburetor by pulling on the priming lever and holding it for about five seconds. Open the throttle by moving the throttle control lever about two thirds across the quadrant. Start the motor, then close the throttle slightly, retard the spark, and adjust the needle valve adjusting screw in and out until the motor runs at the desired speed and hits regularly on all four cylinders. When a good adjustment has been secured for low speed with the motor running idle do not alter the needle valve adjustment any more, but make the intermediate speed and high speed adjustments on the dials shown. First adjust the pointer on the intermediate speed dial moving from the figure 1 towards the numeral 3, and setting it about half way between. Now advance the spark lever and open the throttle

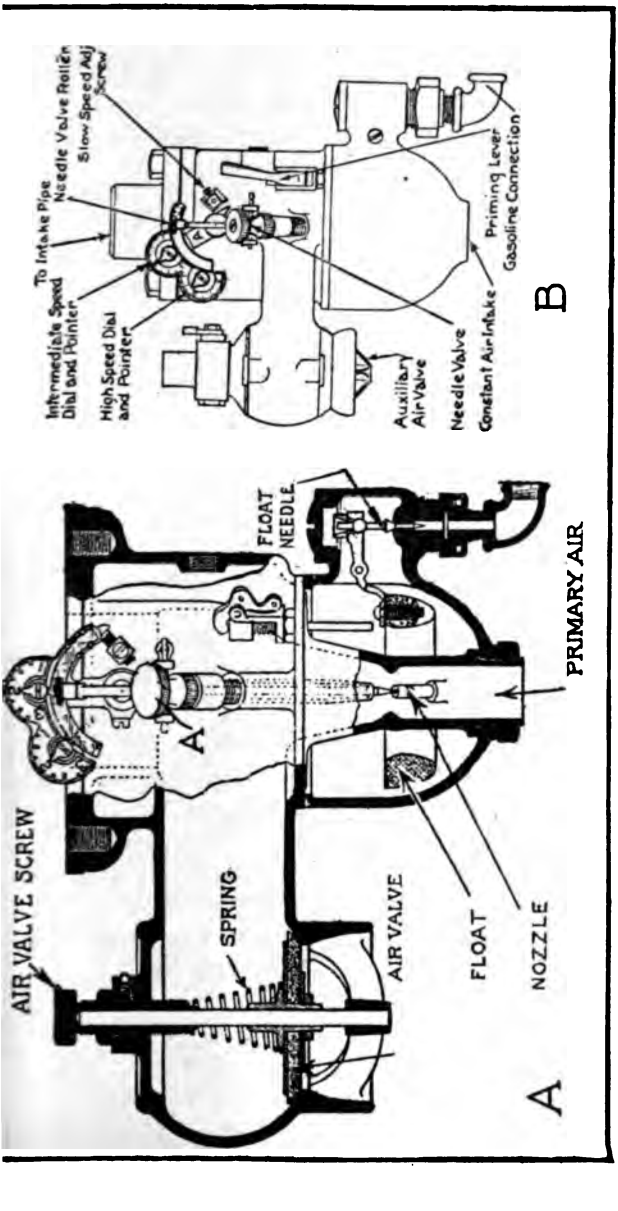


Fig. 195.—Views Showing Construction of Late Model Schebler Carburetor.

so the roller running on the track below the dial is in line w the intermediate speed adjustment dial. If the motor backfi with the throttle in this position, and the spark advanced incre the gas supply by turning the indicator a little more toward th on the dial, or if the mixture is too rich, cut down the gas sup by turning the indicator back towards the numeral 1 on the d until satisfied that the motor is running steadily at the intermedi position of the throttle. Finally, open the throttle wide and m the adjustment with the high speed dial for high speeds in same manner as you have made the adjustment for the intermedi speed. In adjusting the carburetor by this method there is a t dency to give too rich a mixture. Therefore it is advisable wh making these adjustments to cut down the gasoline needle u the motor begins to misfire, and then to increase the fuel sup gradually until the motor hits evenly on all four cylinders. T auxiliary air valve regulating screw should also be adjusted order to secure the best valve openings for high motor speeds w the wide opened throttle. For average running a mixture l in gasoline will give more power and greater speed than a r mixture, but it will be harder to start the motor than if the ric mixture is employed.

Breeze.—The Breeze carburetor, which is shown at Fig. 19 of a conventional pattern having mixture proportion regul by needle valve adjustment for controlling the fuel supply auxiliary air valve springs tension adjustment for varying air admitted. The needle valve is controlled by an adjust screw at the side of the carburetor in one type which is unscre to permit the needle valve to rise out of the spray nozzle screwed in to depress it into the spray nozzle opening and down on the amount of gasoline sucked into the mixture. be noted that an air shutter is placed in the mouth of the p air opening, the purpose of this being to facilitate easy when it is partly closed to produce great air velocity by th nozzle. The Breeze carburetor shown at Fig. 196, B, oper practically the same principle as that outlined at A, except it has a side opening through which the mixture is suppli motor and the gasoline regulating valve is at the top of t

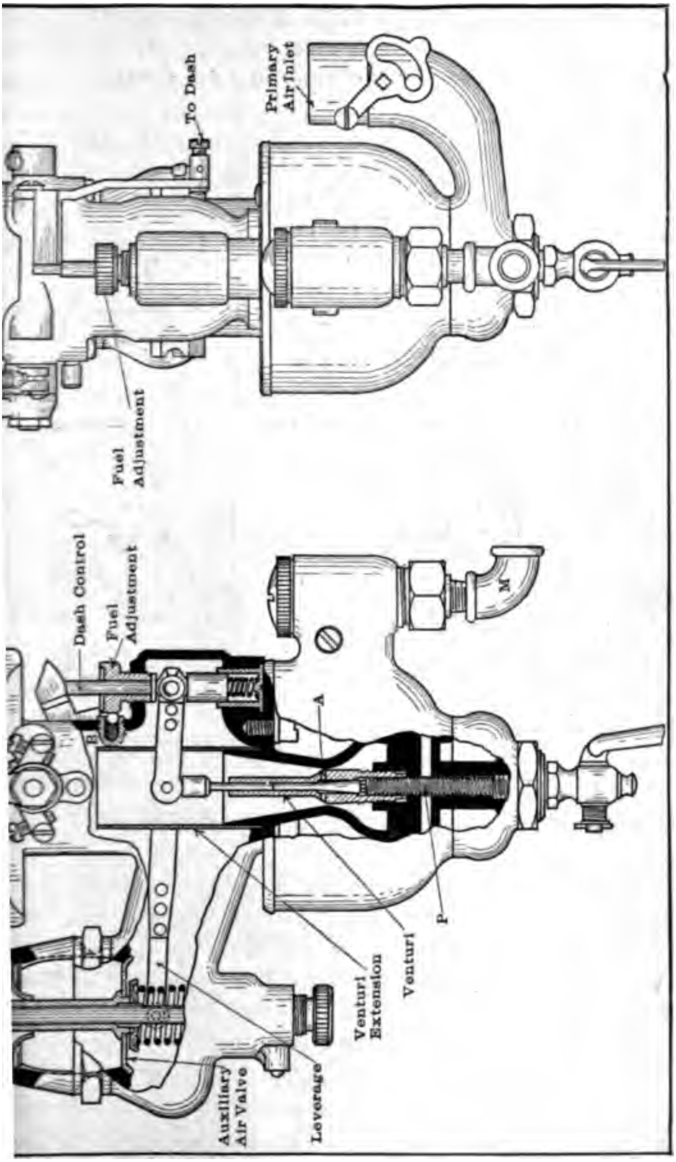


Fig. 195a.—Views Showing 1916 Model Schebler Carburetor Having Mechanical Interlock Between Air Valve and Fuel Regulating Needle, also Dashpot to Prevent Air Valve Fluctuation.

buretor instead of at the side, as is also true of the auxi valve. The fuel supply is regulated by a metal float whi ates the lever to shut off the main fuel inlet control valv

The following instructions are given by the makers Breeze carburetors for adjusting their device: Before chan justments allow the motor to run awhile, heating it to obt mal conditions. Advance spark about to center; then open very slightly and adjust your gasoline (figured dial) u

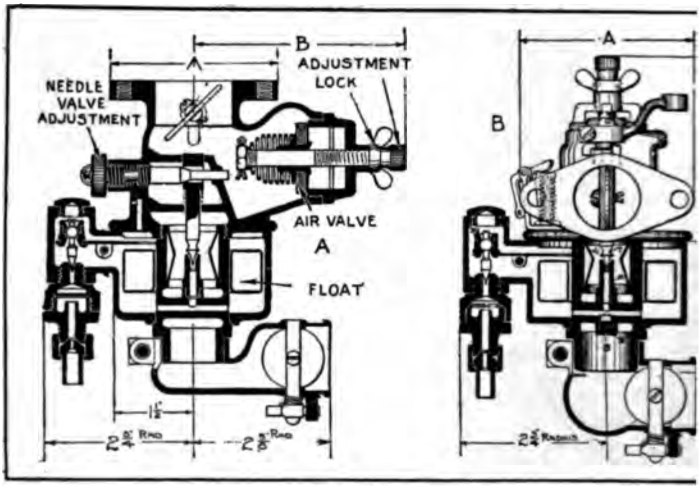


Fig. 196.—Sectional View Showing Construction of Breeze Car

highest speed is obtained with this setting; then open throt and adjust the auxiliary air by either raising or lower adjusting stem on the air valve. If the motor speeds up ately, auxiliary air is correct; if motor fires back throu buretor on high speed, it indicates *excessive* air, and a stem should be drawn up; if slow in picking up, it ind scarcity of air; in that case, lower the adjusting stem. From quarters of a turn to a turn and one-quarter is the usual of the needle valve required. Screwed all the way dow *closed. To open* it turn backwards. ***With the throttle an***

onary, the correct position for the needle valve in any case at at which the engine runs fastest.

f, at the highest speed, the motor picks up perceptibly when uxiliary air valve is pushed further open, then more air is ed. To adjust the auxiliary air valve, loosen the air valve sting wing nut, turn the stem to the left to stiffen the spring decrease the air, to the right to weaken it and give more air. areful, in weakening the spring and giving more air, not to en it so much that the valve does not seat. *Air must not get low speeds or starting will be almost impossible.* Lock the tment securely.

ith the carburetor of the proper size for the motor, as indi- by the manifold pipe, if enough suction is not obtainable n the auxiliary air valve, *with the spring at its lightest ten-* and the motor *at the highest speed*, then a smaller strangling hould be used. With the conditions reversed from those just bed, if the auxiliary air valve spring has to have too great a n to produce the proper results on higher speeds, then a strangling tube is needed to decrease the suction at that so that the spring can automatically regulate the proper nt of air coming through the valve as the throttle opens for speeds. The spring in the auxiliary air valve should never so stiff a tension that with the throttle half way open the ary air valve remains closed. *The auxiliary air valve should ence to open with the throttle to produce the best results.* a change of strangling tubes to meet the above conditions, ll be necessary to readjust the gasoline needle valve for low ls.

o adjust for throttling down the engine to its slowest speed, e throttle on the steering wheel at its lowest point, loosen the tle lever lock screw, and with a screw driver turn the throttle carefully closed till the engine runs slowly enough to suit you. lot cut in the stem shows the way the throttle is set. See that nts between the carburetor and motor are tight. Frequently the motor picks up slowly with throttle open, a weaker will improve matters. Be sure the primer is on the same f the carburetor as the gasoline *inlet*, so the primer plunger

presses down the float lever instead of the float. The mechanism is correctly adjusted before leaving the factoı ing is caused by dirt on the inlet valve seat, or a pooı inlet valve, resulting from improper handling after leaves factory. Therefore, look for dirt and do not try

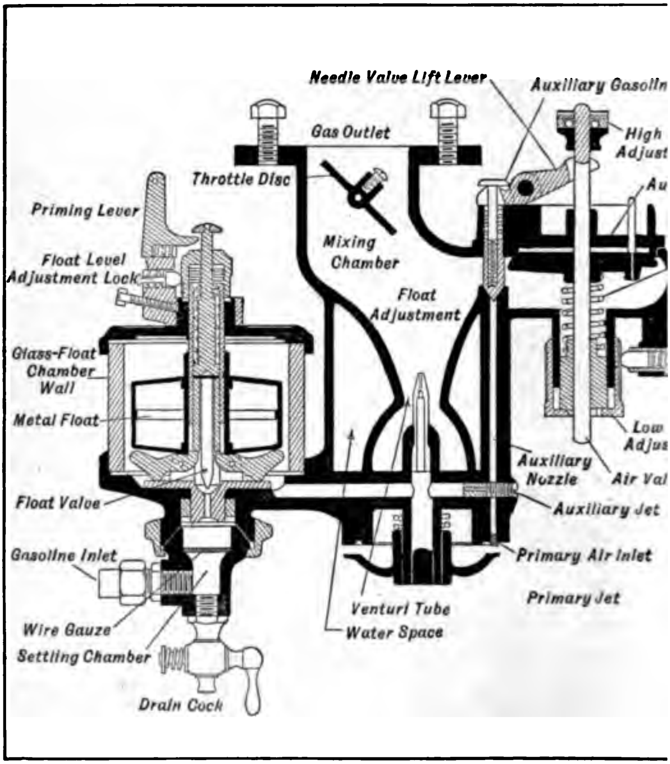


Fig. 197.—Stromberg Two Nozzle Carburetor.

float level. *Never grind inlet valve with emery;* this seat and the valve.

Stromberg.—The Stromberg carburetor shown at Fi form having two spray nozzles, and with a glass wall flo carried at one side of the mixing chamber. In this carl

ight of the fuel in the float chamber may be varied by a float el regulation member, and it is not difficult to determine the oper height as a mark is etched on the glass walls with which e level of liquid must coincide. The spray nozzle is provided th a needle valve to regulate the amount of gasoline sprayed to the mixture. The secondary nozzle is controlled by a needle hich is raised from its seat when the auxiliary air valve is sucked wn due to greater suction produced by increased throttle opening. The valve controlling the auxiliary or secondary jet is lifted r a bell crank and the amount of opening relative to the travel the auxiliary air valve is determined by the position of the justment nut carried on the threaded end of the air valve stem. e amount of air valve opening is regulated by altering the spring sion which tends to keep the valves closed.

A Stromberg carburetor of more recent development, which is own as the H. A., is shown at Fig. 198. In the new Strombergs motor is fed the proper mixture below 25 miles per hour from low-speed jet with air from the primary intake and above that ed the auxiliary air valves come into action, and with it the ondary nozzle, which is interconnected with the air valve. When car is running less than 25 miles per hour the low-speed nozzle y feeds the fuel and above that speed the dashpot comes into y. The piston shown is .01 inch smaller than its chamber, and fuel entering must work its way around the piston. Integral h the piston is a sleeve to which is attached the air valve. thin the sleeve is the secondary needle, which rests upon a seat wn and has at its upper end a button. The spring within the ve holds the needle in position. Should the air valve open, arries with it the needle and at the same time forces the piston nward against gasoline pressure. However, the needle travels y through the distance AB. This is true because movement downd of the air valve carries the needle, but as soon as the button es the nut B it will stop. While the needle is held stationary valve may continue to move, and so move the seat away from valve.

action the piston compensates for lag in the fuel. That is the throttle is opened the air valve is not allowed to open

quickly, and thus cause poor carburetor action, but ins against the fuel in the chamber and opens slowly.

When the fuel is in the chamber and the secondary is opened by increased suction, fuel makes its way up thı holes at the top of the piston, and thence through the slee tube integral with the air valve. The fuel leaving thi

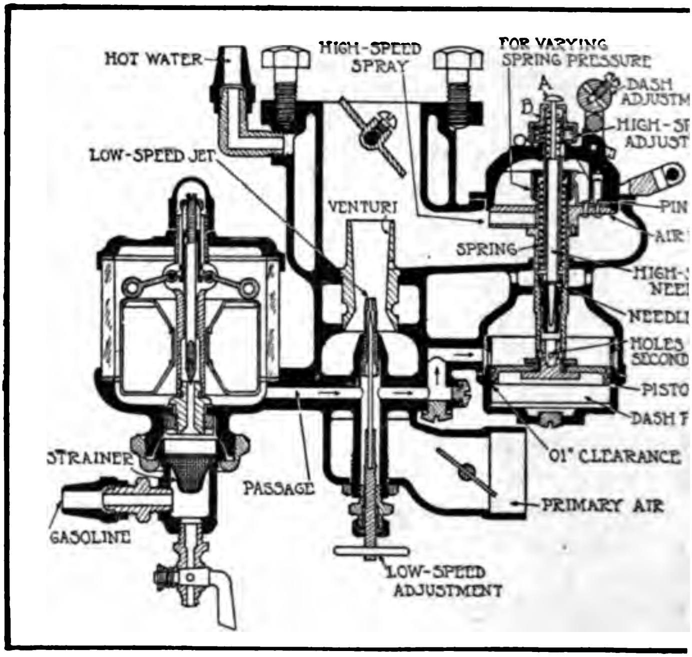


Fig. 198.—Latest Model of Stromberg Two Jet Carburetor w. Pot Controlling Air Valve Movements.

carried away with inrushing auxiliary air and forms t speed mixture. One important feature of this carburetoı in this construction which prevents the secondary fuel sp touching any metal as it leaves the tube, and also gettiı mixing by having the fuel meet the air which is at high The primary nozzle adjustment is in the form of the hand *and* the secondary by means of the knurled nut at the t

r valve. The dash adjustment, a series of levers, not only lifts e secondary needle from its seat, but also locks the auxiliary r valve, so that on starting the engine gets a good mixture with e air supply shut off entirely, provided the primary air intake closed by the butterfly valve.

Holley.—A form of carburetor in which no auxiliary air supply provided is shown at Fig. 199. This is a concentric float and ixing chamber form and the only adjustment possible is by the edle valve which regulates the amount of fuel passing through e standpipe or spray nozzle. At low engine speeds or when the rottle is closed enough gasoline is drawn from the well I to the angling tube J to insure sufficiently rich mixture to make for y starting or to provide just enough gas for idling the motor. l the air must enter through the main air inlet, and before pass- g out of the mixing chamber it must flow into the tube L by ans of the annular passage F, and must brush by the spray zle M with considerable velocity, insuring positive feeding of l due to the pronounced suction effect of the rapidly moving umn of air. In this carburetor the needle valve is set to pro- e the best mixture when the throttle valve is fully opened. e mixture proportions at all other engine speeds are said to be ulated perfectly by the degree of engine suction due to the uliar design of the mixing chamber.

Krice.—The Krice carburetor, which is shown at Fig. 200, is y popular in marine work and operates to some extent on the e principle as the Holley carburetor, the difference being mainly the method of spraying the fuel. Instead of a spray nozzle of usual pattern, the gasoline is spread in a thin sheet in an ular opening between the bottom of the mixing chamber and gasoline vaporizer, and as all air passing through the air inlet t sweep across the face of this vaporizer, it is apparent that ill become impregnated with gasoline vapor. The amount of may be regulated by a gasoline adjustment needle, no source xiliary air being provided.

nith.—The Zenith carburetor shown at Fig. 201 is a type ing a compound nozzle instead of the single spray nozzle in rms previously described. A sectional view through the mix-

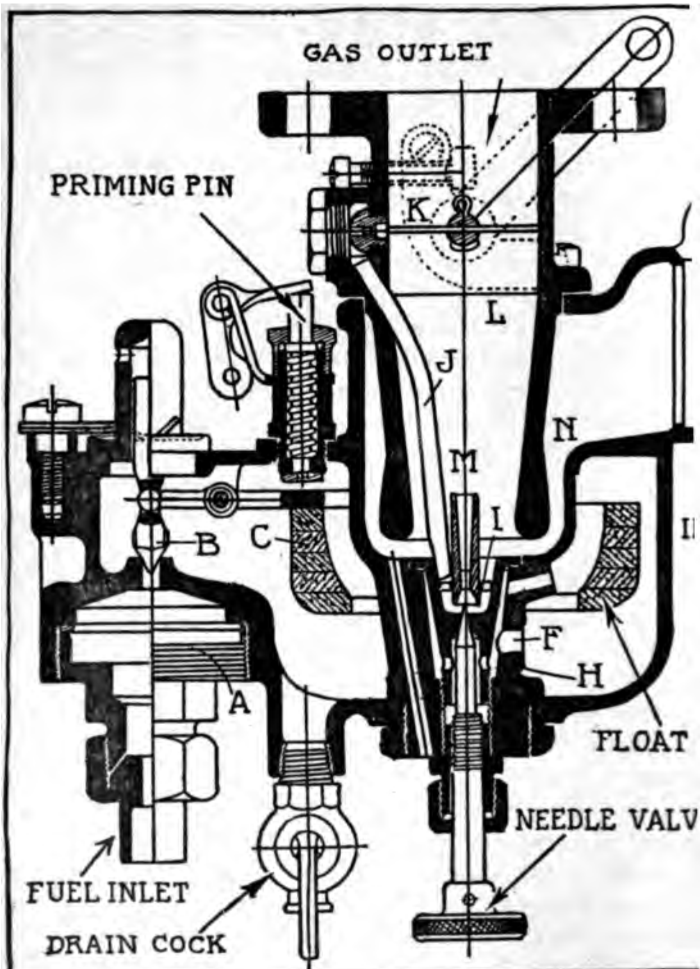


Fig. 199.—Sectional View of Holley Carburetor.

ing chamber is shown at A, while the arrangement of tl mechanism and a sectional view of the compound nozzle is outlined at B. The principle of operation is as follows: Tl *nary nozzle,* or main jet, is shown at G, and receives gasoli

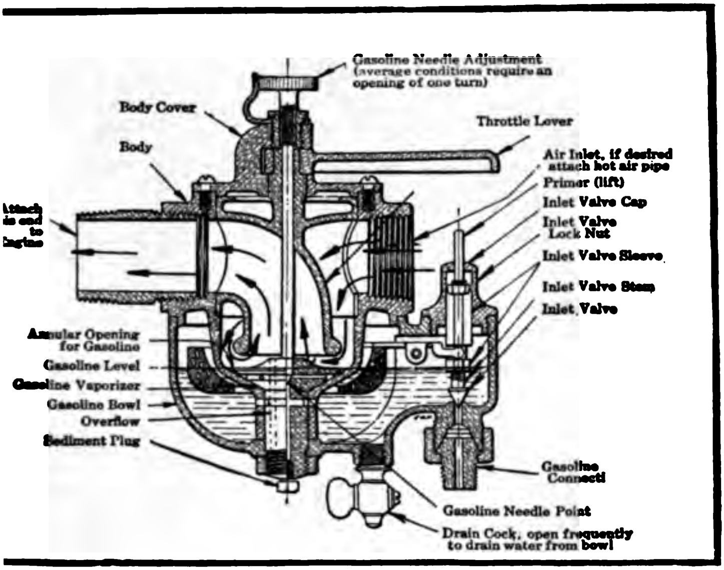


Fig. 200.—Showing Construction of Krice Carburetor.

›at chamber through the channel hole E. It is surrounded · cap jet H, which receives gasoline, through channel hole K, a well Q, open to the atmosphere. This well Q receives a red flow of fuel through the "compensator" I, which, as is seen, is not subjected to the suction of the motor, and has, ore, a constant flow. This compounding of two nozzles, hav- fferent and opposite qualities, is the main characteristic of 'nith principle, and it gives in this new type the same com- ion as in the vertical types.

e slow-speed arrangement used in this type differs slightly the one used previously. It might be termed a "miniature 'etor," and it is made up of the idling tube J, terminating 'one, into which the idling jet P can be screwed up more by means of the knurled adjusting tube O, the air entering ;h holes in this latter part. The mixture formed at this point ; a channel Z, drilled in the carburetor body, which opens he throttle; it is there mixed with the air passing through

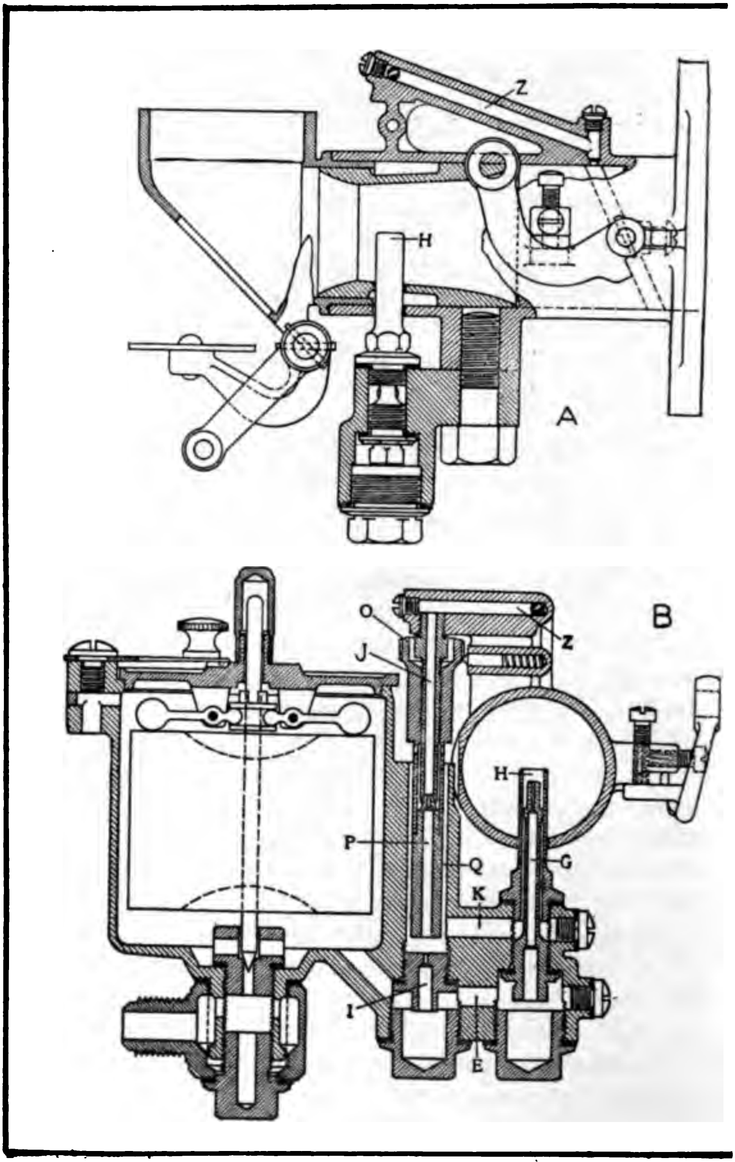


Fig. 201.—View Showing Construction of New Zenith Carbureto

the throttle. When the throttle is only slightly open the suctio there is powerful and atomizes the gasoline perfectly. With throttle a little more opened the compound nozzle comes into pla and this miniature carburetor has no longer any effect. This slov speed adjustment does not interfere with the action of the ca buretor at medium or high speeds. This carburetor finds its appl cation mostly in the case of monobloc engines where the intal passage is cored in and passes in the center of the bloc, from tl valve side to the opposite side. This construction brings the ca buretor at a point which is otherwise unoccupied; it removes o obstruction in front of the tappet covers, and, the carburetor bei higher than usual, interferes less with the other motor accessori In most cases at least one bend in the intake passages is eliminate and it is well known that a bend creates more resistance than tl same length of straight path. It shows how hot air, taken al through a cored passage in the cylinder, is conveyed to the ca buretor. A little flap, actuated from the dash and shown in tl picture in a full open position, may be partially closed, when a the air entering the carburetor will be reheated air; by pulling t control rod completely the flap goes farther and chokes the ca buretor, thus causing the formation of an excessively rich mixtu which is useful for starting a cold motor in severe weather.

Rayfield.—The views at Fig. 202 show the Rayfield carburetc that at A being an exterior view showing all parts to be consi ered in making an adjustment while the interior construction clearly outlined at B. To make adjustments on this carburet the following mode of procedure is observed: First close the need valve. This is done by turning the fuel adjustment to the left un the screw leaves contact with the regulating cam, which indicat that the needle valve is seated. Then turn the fuel adjustme screw to the right for about one and one-quarter turns. The mot may now be started. For more fuel turn the fuel adjustme screw to the right and to decrease the supply turn it to the le This adjustment can only be made at retard or low throttle. Ha ing found the right fuel supply for running slowly, open the thr tle. If backfiring occurs, turn the high speed adjusting screw the right, which increases the supply of fuel at open throttle.

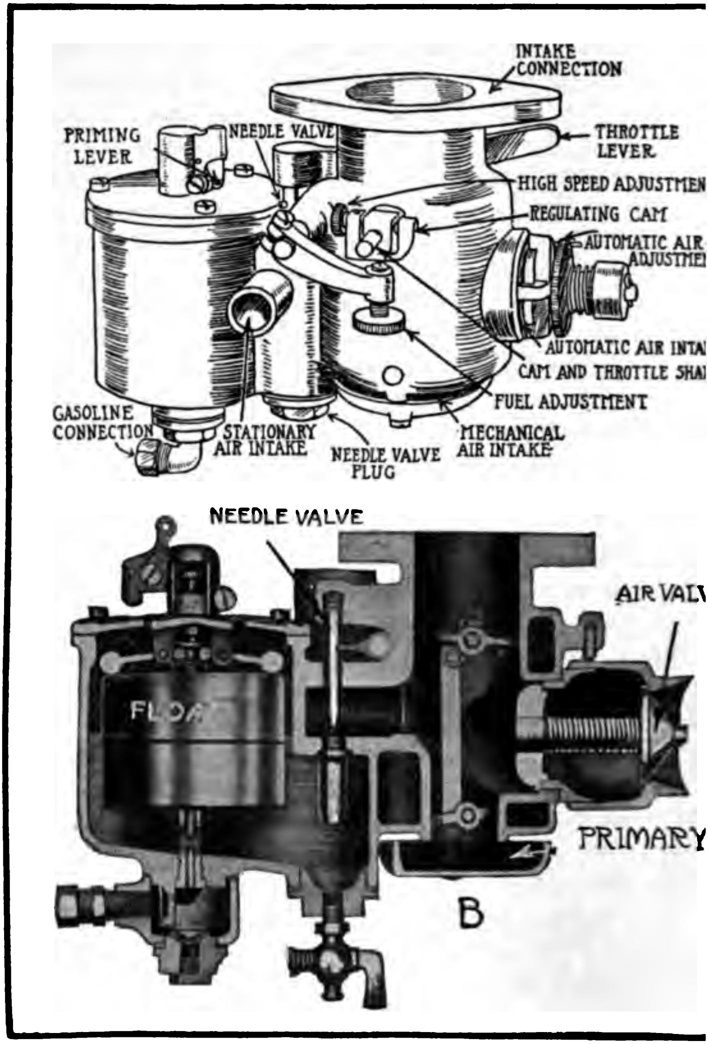


Fig. 202.—Details of the Rayfield Carburetor.

decrease the fuel supply at high speeds turn the **high sp** justing screw to the left. For adjusting the **throttle open** *a screwdriver* to turn the screw in the stop **arm.**

After the right fuel supply has been found for both low a high speeds, the throttle should be opened slowly. If backfiri should occur between low and high speed turn the automatic adjustment to the left. This increases the tension on the sprir which control the automatic air valve. The automatic air val adjustment disk is generally set so that the large spring on t automatic valve has about $\frac{1}{16}$-inch play between the adjusting d and the cap. After the above adjustments are made, in order prove that you have proper fuel supply, press with the finger the automatic air valve, allowing the motor to draw in surpl air. If motor speeds up this indicates that you should use a lear mixture or that you are not getting enough air. The automa air valve adjustment disk should be turned to the right until t motor begins to reduce speed or backfires. Then turn the di back again to the right until the motor runs smoothly. This shou be done with throttle about one-eighth open.

Automatic Speed Regulators.—On some forms of automobil especially those adapted for commercial work, such as taxicabs a motor trucks, it is desirable to provide means for keeping the mot from exceeding a certain predetermined speed. This is usua accomplished by some form of governor acting on the throt which regulates the amount of gas supplied to the engine. Soı of the governors are driven directly by the motor, others are mechanical connection with some moving parts of the vehic There are very few pleasure cars at the present time that ha an automatic speed governing means as the improvement in ca buretors has been such that it is possible to secure close regulati of the engine by the usual accelerator pedal or hand throttle lev A hydraulic governor is used in some models of the Packard truc this consisting of a chamber carrying a diaphragm against whi the stream of cooling water from the circulating pump imping When the speed of the engine becomes too great, it is appare that the flow of cooling water will be more rapid, in which ca the pressure against the diaphragm may be sufficiently great close the carburetor throttle and thus reduce the engine speed.

A form of automatic speed governor which may be mechanical actuated by a flexible *shaft connection* from the vehicle road whe

or from some rotating part of the transmission mechanism or] plant is shown at Fig. 203. This is intended to be carried ε side of the intake manifold and regulates the throttle shutt centrifugal force. The drive shaft mounted on ball bearing ries a governor of such form that as the weights spread apar to augmented motor speed, they will lift a plunger which a bell crank that transfers the vertical movement of the gov push rod to a horizontal movement of the throttle actuatin The throttle shutter stem is in the form of a pinion which n with a rack carried by the throttle actuator. The function coil spring at the end of the actuator is to keep that member

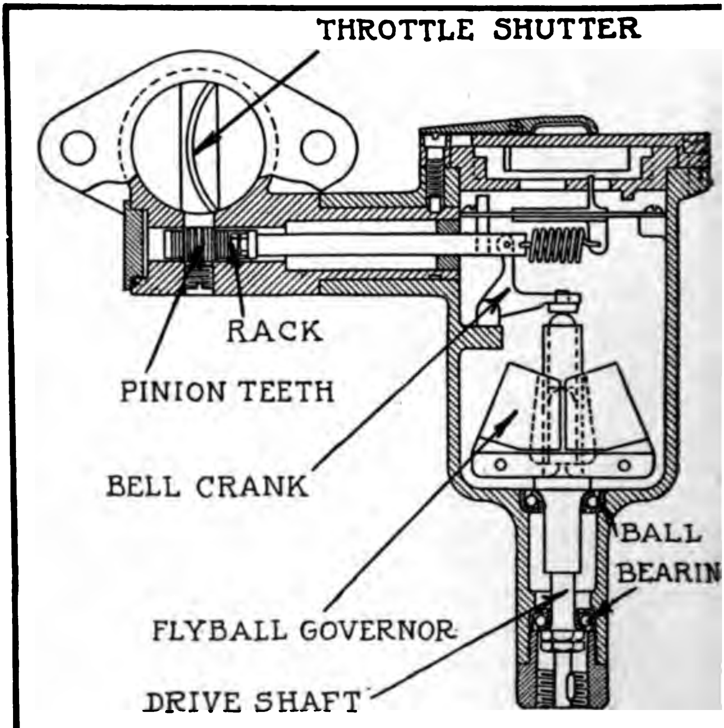


Fig. 203.—Centrifugal Governor Used to Cut Down Gas Supply Prevent Exceeding Predetermined Motor Speed.

back and the throttle open. When the vehicle speed becom higher than that for which the device is set, the bell crank w be raised by the weight actuated plunger and the throttle val closed until the engine speed, which is reduced as the gas supp is diminished, slows down the fast running vehicle. If desir it is possible to drive the governor from the engine shaft, in whi case it will regulate engine speed rather than be actuated the vehicle speed. An adjustment is provided at the top of t device by which it may be set for various speeds as desired.

Systematic Location of Carburetion Faults.—Having on learned how to adjust a carburetor to supply the properly prop tioned mixture for different operating conditions, the repairm will realize that he has found a remedy for many motor ills, b cause a large proportion of motor troubles, such as misfiring, bac firing in the carburetor, loss of power, etc., are generally due some faulty adjustment. There are, to be sure, a number of oth troubles likely to occur, and while the symptoms are similar those caused by ignition system faults, the operator who is famili with carburetor action should have no trouble in locating the quickly and ascertaining positively if they are the result of faul carburetor action or due to the ignition system. Taking up t various causes which contribute to loss of power, misfiring a trouble in starting the motor, we have: dirt or water in the ca buretor, clogged fuel pipe, obstructed spraying nozzle, clogged gas line filter, leaky metal float or fuel logged cork float, poor or sta gasoline, a loose throttle valve or connection and air leaks in t inlet manifold. If the motor refuses to start and the igniti system is known to be in good condition, the fuel tank may emptied, the gasoline line shut-off valve closed (it may jar part or wholly in the "off" position), there may be dirt or water the carburetor or a choked fuel pipe, or perhaps the fuel level too low in the float chamber. As a cold motor and stale fuel a the most common hindrances to prompt starting, the first step to prime the carburetor and fill the float chamber with fresh gas line. Almost every carburetor is provided with a "tickler," a in most cases priming is all that is needed to supply gasoli enough to insure prompt starting of the motor.

However, if the motor still refuses to operate the trouble i deeper seated and should be found by a systematic search. T locate the trouble without undue delay the various parts of th fuel system should be examined in turn. First, the tank shoul be looked into to see if it contains sufficient fuel. The filter scree of the carburetor should be removed and cleaned, since the fin mesh is very likely to become clogged with dirt or lint filtered ou of the fuel. If the wire gauze is in good condition, examine th pipe line for obstruction. Test the supply pipe by opening th drain cock under the float bowl of the carburetor; if the pipe i constricted, but little or no fuel will be forthcoming. If no gasoli issues and there is plenty of fuel in the tank and one is sure th drain cock is not stopped up, it is reasonable to assume that th supply pipe is choked and it should be removed and cleared out previously described. If the obstruction is not in the pipe it m be located in the shut-off valve, or perhaps in the fuel line filt

An obstructed spraying nozzle or jet will sometimes be fou the cause of trouble, as the opening in this standpipe is very sma even a tiny particle of foreign matter will be enough to constr the orifice and so deprive the motor of the proper amount of fu Flooding the carburetor will sometimes dislodge the obstructio but if it does not the spray nozzle should be removed and a fi wire poked through from one end to the other. Compressed may be used as previously outlined. Fine particles of lint, so times work through the strainer and collect into a ball, which flo about and is drawn into the nozzle by the suction of the engi In cases of this sort the motor will start easily, but invaria commences to misfire, slow down, and finally come to a stop. T peculiar behavior is caused by the greater suction at high spe which draws the foreign matter in the jet and so chokes the b but as the motor slows down and the suction decreases the struction will fall away from the jet opening. It is someti possible to remedy this trouble by racing the motor and ope the throttle valve suddenly, which will give momentary incre suction, often sufficient to suck the particles of lint through nozzle opening.

It may be observed that in those carburetors where no fuel r

lating means is provided, that the height of liquid in the sprayi jet is an important adjustment. The repairman should not be hasty about altering the position of the spray nozzle in the mixi chamber. If the jet is placed too high the fuel level will be co siderably lower than it should be, and while the nozzle will th feed enough gasoline for high speeds, owing to the increased su tion, the vacuum created at low velocity will not be sufficient draw up the required quantity of fuel. On the other hand, if t nozzle is placed too low, the fuel level will be raised unduly a the carburetor will show a tendency to flood. As the proper a justment can be determined only by experimenting, when the noz is so adjusted that the motor will get the proper amount of fu at both high and low piston speeds the spray jet should not disturbed again. The only way it is possible to raise the noz is by inserting thin washers made of brass or copper shim stc between the spray nozzle and its seat. The only way the noz can be lowered is by removing the packing washers, sometin placed between the nozzle and its seat in the mixing chamb Alteration of nozzle position is work for the carburetor expert on

If the repairman notices continuous flooding or dripping the carburetor, this indicates either a badly seated needle valve, leaking metal float, or a fuel-soaked cork float. If the float conti valve itself is at fault, this is probably due to poor seating. T valve should be carefully ground in by using a small amount powdered grindstone dust and oil. When doing this work, ca should be taken to keep the valve stem in a vertical position, a when finished both the valve and its seat should be smooth a bright. If the valve spindle is bent, remove the float, place t bent spindle on a block of wood, carefully straighten it with a fe taps from a light hammer. This applies more to the form valve passing through the center of the float as indicated at F 201, B, than to the type shown at Figs. 199 or 200. In cases continual flooding examine a metal float for minute holes or lea seams, which must be soldered up. Owing to the extreme thinne of a hollow metal float, care must be taken to heat the metal little as possible. As instructions will shortly be given for repai ing metal floats and *finding the leak*, no trouble should be expe

enced in making repairs to this member. The use of hard or silv
solder, which requires a blow pipe or torch, should be left to tho
sufficiently skilled to manipulate the heating member properly
In order not to disturb the balance of the float, only a little sold
should be used, and care should be taken that none drops insid
the float shell.

Mention has been previously made of the way a cork float wi
gradually absorb the liquid owing to its porous nature and how
will lose its buoyancy when it is fuel soaked. The remedy is
simple one, the cork being placed in a moderate oven so it will
thoroughly dried out and afterward it is given a couple of coats
shellac to make it liquid proof. It will be found that shellac di
solved in grain alcohol will resist the action of gasoline bett
than that dissolved in wood alcohol. In some carburetors, t
float is carried directly by the needle valve spindle, which h
the valve at the top so that it may close the fuel opening wh
the gasoline reaches the proper level If the level is too low t
float may be shifted on this spindle to ride at a slightly hig
level which permits the float chamber to fill up more. If the fl
level is too high the float may be lowered on its spindle in ord
to close the valve sooner or when the float chamber has less ga
line in it.

A cause of trouble in which no control of the motor may
had by moving the throttle lever is due to loose throttle conn
tion. It sometimes happens that the set screw used to fasten
butterfly or disk valve to its spindle becomes loose and allows
shutter to shift about and thus partially or wholly close the op
ing. In this case the motor cannot be speeded up. If the v
drops into the pipe in such a way that it does not obstruct i
any extent it will be found impossible to slow down the moto
there is no means of cutting off the supply of gas to the cylin
If the mixture volume is controlled by a sliding shutter as in
Schebler model E carburetor, shown at Fig. 194, B, this
stick in either the open or closed positions, in one case permi
the motor to speed up to its limit, in the other extreme it will
vent speeding up. Troubles with the throttle valve or conne
are easily recognized because the motor will refuse to resp

the movement of the hand lever. An uncommon source of troul may be a bit of stray waste left near the intake opening or t primary air supply when cleaning the motor. This waste may sucked into the air opening and will cause trouble by reduci the amount of air supplied the mixture. Air screens also cl with dirt at times.

It is a fact well known to experienced repairmen and motori that atmospheric conditions have much to do with carburetor i tion. It is often observed that a motor seems to develop mc power at night than during the day, a circumstance which is ; tributed to the presence of more moisture in the cooler night a Likewise, taking a motor from sea level to an altitude of 10,0 feet involves using rarefied air in the engine cylinders and ; mospheric pressures ranging from 14.7 pounds at sea level to 1(pounds per square inch at the high altitude. All carburetors w require some adjustment in the course of any material chan from one level to another. Great changes of altitude also have marked effect on the cooling system of a car. Water boils at 2 degrees F. only at sea level. At an altitude of 10,000 feet it w boil at a temperature nineteen degrees lower, or 193 degrees

In high altitudes the reduced atmospheric pressure, for 5,0 feet or higher than sea level, results in not enough air reachi the mixture, so that either the auxiliary air opening has to increased, or the gasoline in the mixture cut down. If the us is to be continually at high altitudes he should immediately pı chase either a larger dome or a smaller strangling tube, mentic ing the size carburetor that is at present in use and the type motor that it is on, including details as to the bore and strol The smaller strangling tube makes an increased suction at the spr nozzle; the air will have to be readjusted to meet it and you c use more auxiliary air, which is necessary. The effect on t motor without a smaller strangling tube is a perceptible sluggis ness and failure to speed up to its normal crankshaft revolutioı as well as failure to give power. It means that about one-thi of the regular speed is cut out. The reduced atmospheric pressu reduces the power of the explosion, in that there is not the saı quantity of oxygen in the combustion chamber as at sea level;

increase the amount taken in, you must also increase the gasoline speed, which is done by an increased suction through the smaller strangling aperture.

Frost on Intake Manifold and Carburetor.—This phenomenon occurs when the carburetor is delivering a good mixture and there is moisture in the atmosphere. The cold of the vacuum in the manifold and carburetor, created by the suction stroke of the motor, absorbs whatever warmth may exist in the air coming in so rapidly that the suspended moisture in the air outside is condensed and deposited on the outside of the manifold in the same way as a pitcher of ice water "sweats" in summer. The carburetion must be good if this condition takes place. If there is no frost on the manifold, the carburetion may still be good and low grade gasoline be the reason for the non-existence of the frost, as the poor gasoline will not evaporate until it comes in contact with the hot cylinder walls. While frost is indicative of a good mixture, still it shows the presence of atmospheric moisture and in this way is a warning that the air should be *dried out* before reaching the carburetor to obtain the best results from this good mixture. The easiest and most effective method of drying the air is the COLMAC system of a clamp on the exhaust pipe and the air conveyed from it to the carburetor through a flexible tube, as shown at Fig. 208, A.

Soldering a Metal Float.—In repairing or making sheet metal floats, such as are used in the gasoline chamber of the float feed carburetor, one often experiences some difficulty in sealing up the small vent which makes the float air and liquid tight. When a metal float fills with gasoline, it becomes heavier and the float level is altered so it is imperative that the fuel be expelled from the interior and the hole sealed. The usual way to do this is to first locate and enlarge the hole through which the fluid reached the float interior. To locate a leak, the float is held under the surface of boiling water, which evaporates some of the gasoline inside the float and evolves a gas which indicates the hole by escaping through it, because of the pressure inside the float. The hole is then marked, and made larger with a needle drill. Another small hole is made in the float so the interior can be thoroughly cleared out

by air pressure or by placing the float in an oven where the he will evaporate the gasoline. After the float is emptied, it is nec sary to close up the openings. This may be done with an ordina soldering iron, though most mechanics having the facilities pref to braze the opening because by this means one can seal it a use a minimum of metal, which is not liable to upset the balan of the float and interfere with the level in the spraying tube. brazing a joint or vent in a perfectly tight receptacle, the job often a failure because the air contained in the float becomes heat and produces a pressure that may result in having bubbles in t

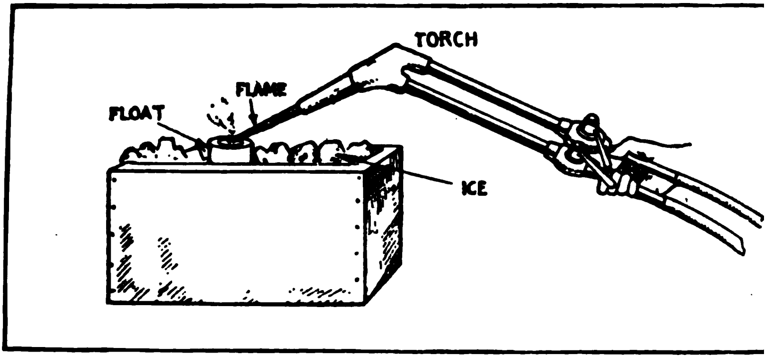


Fig. 204.—Method of Brazing Hollow Metal Float.

brazed seal. To make it possible to close the opening in a positi manner, the copper or brass float may be placed in a bcx of i as shown at Fig. 204, this tending to keep the air contained in t float cool despite the heat imparted to the float by the brazi flame.

Emergency Manifold Repair.—It is not difficult to repair leak in a built-up manifold of brass or copper tubing owing to t ease with which these materials may be soldered or brazed. Wh the manifold is a casting, as on the engine shown at Fig. 205, is not easy to repair a break if the member is of aluminum whi is the material commonly used for this purpose. While it is n impossible to solder aluminum, the necessary solder and fl are not apt to be at hand and in addition, the operator must

led in order to manipulate the special solder successfully. Th
togenous process, or oxy-acetylene welding may be employed
in new metal in the break and form a permanent repair.
hops are not provided with this equipment, even though t
may recognize its value. In fact, in many small shops there wo
not be enough welding work to make it a profitable investment
the value of the o
gen flame method
burning out carb
not generally r
nized. At Fig
an emergency re
an inlet manifo
had cracked r
point of junc
tween the
and the ste
lined. Thi
complished
ing a mold

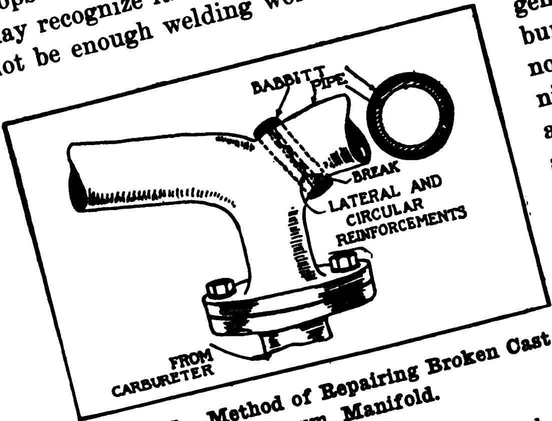


Fig. 205.—Method of Repairing Broken Cast Aluminum Manifold.

break, leaving a vent at the top through
ed to form a ring around the fr
a reënforcement.
d to eff

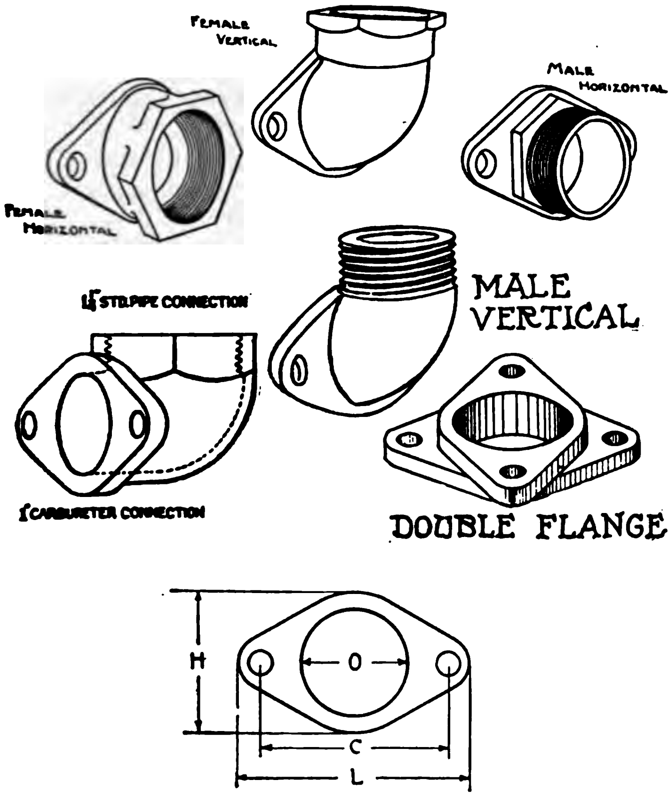
l an up-to-date ignition system often transforms one that will give very satisfactory results. While es of carburetors may be secured in sizes that will d cars, it is sometimes necessary to adapt a special . engine for which it was not intended. Perhaps ing device is larger than the one it is to replace

ing Conventional Method of Installing Top Outlet Carburetor on Short Cast Aluminum Manifold.

nent of the air valve or float chamber may be not be installed in the same way as the one orig- with the power plant. A typical carburetor in- rly shown at Fig. 206. It will be observed in this t manifold is of T form, having a very short stem, buretor is placed close to the cylinders. If it were e this member *with one of* different make it might

be difficult to have the new carburetor fill exactly the same space and bolt to the manifold in the same way as the old one.

In cases of this kind some rearrangement of parts would be necessary and special adapter fittings might be needed. A number of these is shown at Fig. 207. Some carburetors have a thread cut on the outlet pipe instead of a flange, and if the old device were of the flange type an adapter fitting would be necessary to enable one to install the new mixer. For instance, if the outlet pipe had a male thread, the female horizontal fitting shown would be necessary. If the outlet pipe were provided with an internal thread, it would be necessary to use the male horizontal fitting. While these are devised for side outlet carburetors, they may be used equally well with top outlet carburetors having a threaded outlet pipe. It is sometimes necessary to couple a top outlet carburetor where a side outlet was formerly used. In this case the female vertical fitting would be necessary with a male threaded outlet pipe, while the male vertical fitting would be needed with a carburetor having an internally threaded top outlet. Fittings of this nature are also made with a flange at each end instead of with a flange at one end and a thread at the other. It is often necessary to use a carburetor slightly larger than that supplied with the engine, or vice versa. In this case fittings having a different size hole at each end are needed. The one illustrated has a 1¼-inch standard pipe connection at one end to receive an externally threaded outlet pipe while the flange is the standard size for a one-inch carburetor. Suppose it is necessary to couple a carburetor having a flange pointing in one direction to a manifold in which the flange was at right angles to that on the carburetor. In cases of this kind the double flange fitting shown would permit of attaching the carburetor to the manifold. While a number of standard dimensions have been proposed for carburetor flanges and corresponding members on manifolds, there is still considerable variance in flange sizes for the same size carburetors. In the lower part of Fig. 207 a typical flange is outlined with the dimensions indicated by letters. The dimensions for different sizes of Breeze carburetors that correspond to the letters may be clearly ascertained from the tabulation beneath the cut.



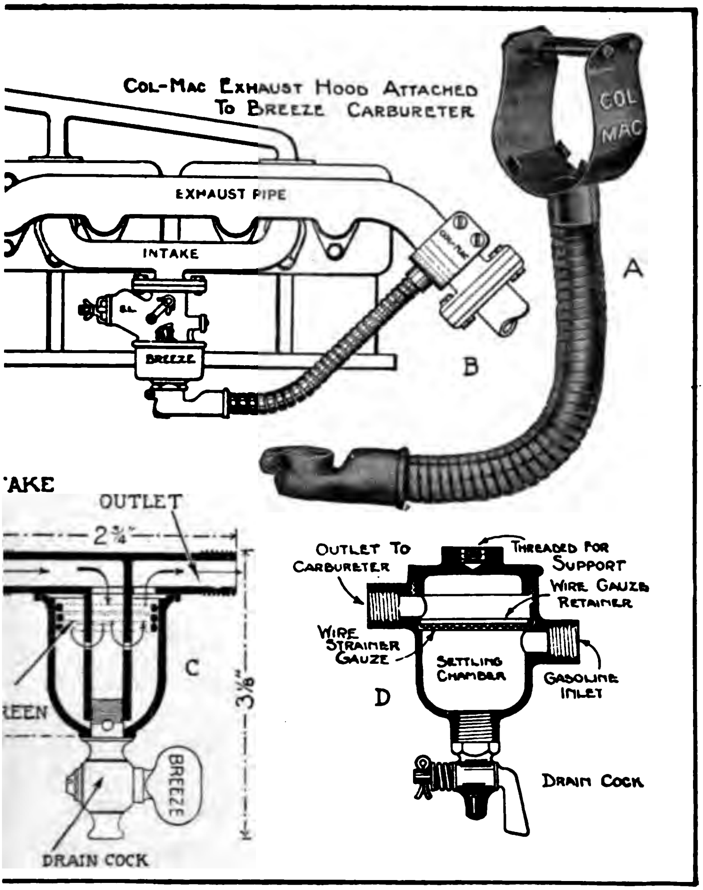
Details of Sizes.

Size	H	C	L	O
¾ in.	1½ in.	2 in.	2½ in.	15/16 in.
1 "	1¾ "	2 11/16 "	3¼ "	1¼ "
1¼ "	2 "	2 11/16 "	3¼ "	1½ "
1½ "	2¼ "	3 "	3¾ "	1¾ "
2 "	2¾ "	3¼ "	4½ "	2¼ "

207.—Showing Adapter Fittings for Use in Fitting Carburetc Also Dimensions of Typical Carburetor Flange.

It is very important when the low grade fuels that are bei supplied at the present time are used to supply some form preheating arrangement for the primary air in order to insu prompt vaporization. While all of the new engines are being fitt up in this manner, a large number of cars are in daily use that d not have this desirable refinement of detail. When trouble experienced due to the use of cold air, especially in cold weath the repairman may often suggest the use of the warm air attac ment as a practical remedy for the trouble. A typical attac ment of this nature is shown at Fig. 208, A. This consists of clamp member adapted to bolt around the exhaust pipe and supp the warm air to the primary air intake of the carburetor throu a length of flexible metallic pipe. These fittings may be obtain to fit various sizes of exhaust pipe, and for different carbureto The one shown at A is suitable for the Breeze carburetor, and installed as indicated at E.

When piping from the fuel tank to the carburetor it is oft desirable to include a filter or strainer in the pipe line in ord to prevent dirt from passing into the carburetor. This is anoth refinement that is found on practically all cars of recent ma facture, but which was often omitted on earlier models. Two for of these filtering devices are shown at Fig. 208. That at C is form that insures the most positive separation on account of usi three filtering screens. The gasoline from the tank enters t intake pipe and follows the course indicated by the arrows throu the filter screens and back into the pipe line through the out opening. Any sediment or dirt will collect in the lower porti of the device and may be drained off by opening the drain co A simpler device operating on the same principle is shown at In this case the gasoline enters the lower portion or settling ch ber, where dirt and water will fall to the bottom on account their weight, and only clean fuel that can pass through the w gauze used as a strainer can flow out of the outlet opening to carburetor. Care should be taken in installing carburetors to a using pipe fittings having sharp bends unless absolutely neces Very often all the added efficiency that can be obtained by ch *ing carburetors* will be lost when installing a new one due to



8.—**Illustrating the Use of Hot Air Connection for Carburetor and Breeze Strainers for Use in Pipe Lines.**

elbows or other fittings of this nature, which impede the gas. While it is unavoidable in some cases, such as when outlet carburetor is to be adapted to a manifold intended r a top outlet form, endeavor should always be made to a carburetor of the same general pattern as that removed. ke made by many *repairmen when* changing over fuel lines

is to use tubing having too small bore or to use material that a seam running its entire length. Only the best annealed copper tubing should be used for fuel lines, and this must b the seamless form. Hard brass tubing or standard brass pi apt to crystallize and break, due to vibration, whereas the copper tubing can be bent more easily to clear parts of the mec ism or cross members of the frame, and is not liable to kinl when bending as the hard tube is. Tubing having $\frac{1}{8}$-inch (. inch) bore will be satisfactory for small engines such as use motorcycles, but for the range between ten and twenty-five h power the tubing should have at least $\frac{1}{4}$-inch (.250-inch) l For larger engines tubing with a bore of $\frac{5}{16}$ inch or $\frac{3}{8}$ inch be sufficient. The piping conveying compressed air or exhaust to produce pressure in the fuel tank should be larger than employed to convey the fuel, the larger sizes being needed the exhaust gas system on account of its pressure being lower the air stream from a pump. All fittings should not onl threaded on, but should be soldered as well to insure tight jo Care should be taken to fasten the fuel pipe to the frame substantial metal clips, so that it cannot vibrate, which may c the joints to open up and leak.

Simple Oiling Systems.—Insufficient lubrication or the us poor lubricating oil will produce the same overheating sympt that defects in the cooling system do. There is this advant when the troubles are caused by poor lubrication, it is very to trace the trouble owing to the simplicity of practically of the modern methods of engine lubrication. A prominent manufacturer claims that all of the lubricating systems in may be divided into ten classes, as follows: No. 1, simple spl No. 2, constant level splash; No. 3, pump over and splash; N force feed and splash; No. 5, pump over; No. 6, separate f feed; No. 7, force feed; No. 8, full force feed; No. 9, slide v motor; No. 10, oil fed with fuel. It is contended that the c acter of the lubricating system employed is an important p to be considered in selecting suitable grades of oil, but while is true to a certain extent, it is not necessary to differentiat *closely as most* oil manufacturers advise between the various

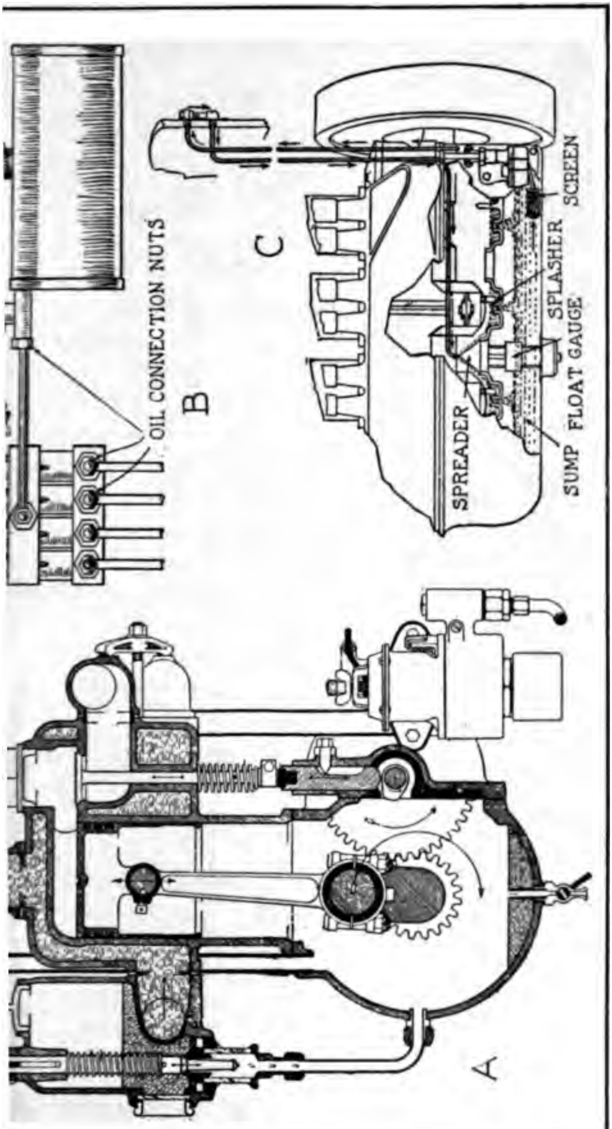


Fig. 209.—Simple Oiling Systems That Have Received Wide Use. A—Method of Supplying Lubricant on Early Hupmobile Models. B—Sight Feed Oiling Systems. C—The Constant Level System Used on Overland Cars.

tems, as careful analysis of their published recommendation shee shows the same oil to be recommended for engines having total different lubricating systems in some cases. The writer believ that it is not necessary to divide the lubricating systems into mo than two general groups, these being the "circulating" system an the "all loss" system. In the former the oil originally supplied th container or sump of the motor is used over and over again, bein circulated to the bearing surfaces in contact by the moving par themselves, or by some positive form of circulating pump. In th other group the crankcase of the motor is filled to a fixed leve The lubrication of all parts takes place by splash, and the lo is made good by feeding oil into the crankcase from some auxiliar source. In the "all loss" systems the object is to feed the lubrica into the crankcase at about the same rate as it is consumed. Aft oil has been used for a time in a circulating system it is necessar to drain off the crankcase and thoroughly clean out that memb after four or five hundred miles running, as the oil depreciat in value as it is used. In the "all loss" systems it is not necessar to drain out the crankcase as often as in the circulating syste because of the constant addition of fresh oil. The principal gro classification may be understood by referring to the simple oili systems outlined at Fig. 209. That at A may be considered good example of an "all loss" system in which the oil is allow to drip into the crankcase from a reservoir to replenish that us in lubrication. It will be observed that the crankcase is filled a certain height and that the connecting rod will dip into t oil at the end of every down-stroke of the piston. As it swe through the oil it throws it about in the engine interior, and there lubricates all moving parts. In order to supply more oil when t engine speeds up, the oil feed regulating valve is adapted to raised by an inclined plane connected with the throttle as it opened to accelerate the engine speed. This method was used some of the early Hupmobiles.

Another example of an "all loss" system with individual le to some of the bearing points from a sight feed lubricator is sho at B. In this case the lubricant is carried in a tank from wh *it is supp*lied to the sight feed manifold fitting by displace

due to exhaust gas or air pressure directed against the oil in t tank. The pipes lead to bearing points in some cases, to t engine cylinders or crankcase in others. The amount passi through may be regulated by adjusting needles at the top of t manifold fitting.

An example of a simple circulating system is shown at Fi 209, C. In this the bottom of the crankcase acts as a sump or oil container. When the engine is started, a gear pump, which is positively driven by the engine, draws oil from the sump through a pipe connected to a filtering screen. It is discharged from the pump through a tube leading to a sight feed fitting or circulation indicator on the dash. From this it goes to the troughs under the connecting rods, keeping these filled to a constant level, the surplus oil overflowing back into the sump.

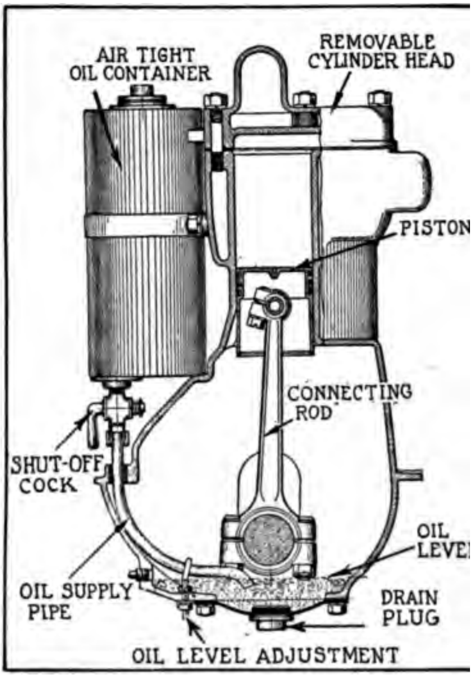


Fig. 210.—Saxon Vacuum Feed Oiling Syste

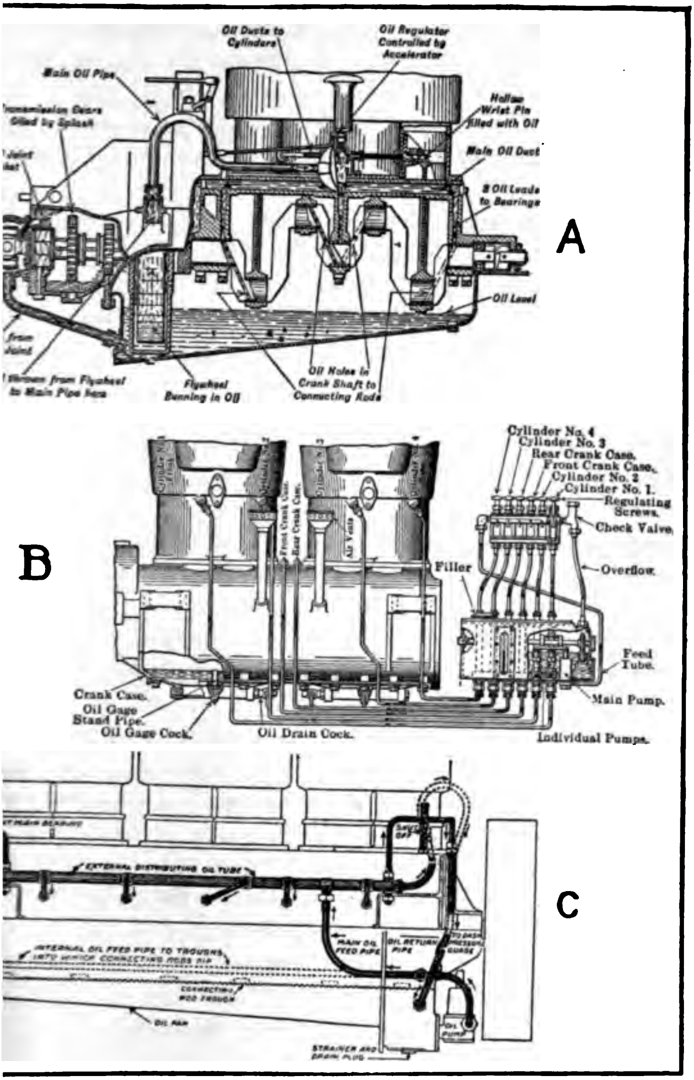
A representative flywheel splash system is shown at Fig. 2 A. In this the bottom of the engine is inclined to form a w in which the flywheel runs. In turning, the flywheel projects t oil which it lifts by adhesion from its periphery tangentially, d to centrifugal force. Part of the oil thrown off is caught by a tu opening into the path of the oil, and is led forward to a main duct passing first through an oil feed regulator controlled by

accelerator. A portion of the oil from the main duct is conveyed to the cylinders, the remainder is directed to the three main bearings. Passages drilled into the crankshaft distribute the oil from the main bearings to the connecting rod big ends. Part of the oil thrown off by the flywheel is deflected against the transmission gears by the gear case cover and part flows to a pocket which lubricates the universal joint. A pipe leading from the universal joint to the bottom of the crankcase insures the return of the lubricant to the bottom of the crankcase.

An "all loss" system in which the feed to replenish the loss is by individual leads from a mechanical oiler is outlined at Fig. 211, B. While this system was formerly very popular, it has been practically done away with at the present time, owing to mechanical complication and liability of trouble. In this system a main oil pump is carried by the oiler casing which serves to house the mechanism, and also acts as a container for lubricant. The pump supplies the top of the manifold fitting through a main feed tube. The various feeds are regulated by needle valves, and after the supply has been set to suit the oil is pumped out of the sight feed glasses by individual pumps through leads which go to the cylinders and to the front and rear crankcase compartment. The idea is to set the feed so that oil will be supplied only in such quantities as are necessary to make up the loss.

At Fig. 211, C, a lubricating system is shown in which oil is pumped from a sump to an external distributing oil tube which leads to the main bearings, and which also supplies a lubricant to the crankcase interior. An internal oil feed pipe is also connected to the pump and is used to fill the troughs into which the connecting rods dip.

The Constant Level Splash System.—The illustration at Fig. 212, A, shows very clearly the interior of an engine in which the constant level splash system of lubrication is used. The supply is carried in the sump integral with the bottom of the crankcase and the height of oil is clearly indicated by an oil level indicator which is actuated by a small float submerged into the oil. As long as there is sufficient oil in the sump the oil level indicator will be *at the top of* the gauge. As soon as the supply diminishes, the



ig. 211.—Oiling Systems for Multiple Cylinder Engines.

oil level indicator will follow the movement of the float anc show the deficiency in a positive manner. It will be observec the oil level in the crankcase is determined by the position c overflow pipe. This can be moved in such a way as to alte level. The oil is drawn out of the sump by a gear oil pumj directed by means of an integral oil duct to the main bea of the engine.

Distributing Pump Systems.—The method outlined at 212, B, is a circulating system in which the various bearing ı are kept lubricated by oil drawn from a sump by a geare pump, which also combines a distributing mechanism so tl will be supplied to the various bearing points by feeding of the oil leads in turn. Some of the leads go to main beaı others supply the camshaft. The interior of the engine is l cated by splash as the connecting rods are provided with spla at the lower end to distribute the lubricant around the e interior.

Forms of Oil Pumps.—The important element of all th culating systems is the pump which keeps the oil in circul Pumps have been made in various forms, the two main used at the present time being the plunger and the gear p Various applications and designs of pumps are shown at Fig. That at A is a plunger pump, which is actuated by an ecce strap passing over an eccentric on the camshaft. As the cam revolves the pump plunger reciprocates in the pump barr cylinder. Each time the plunger lifts the inlet check valve p directly over the intake pipe opens and oil is drawn out o sump, first passing through the filter screen, until it fill space in the pump cylinder left by the upward movement o plunger. When the plunger descends, a check valve opens permits the oil in the cylinder to pass out and into a main tributing duct. The splasher or scoop used on most engines its path through the oil in the trough is clearly shown in view.

The pump form at B is also a plunger pump, but is the where a separate pump is provided for each lead from the me *ical oiler.* The pump plunger is raised by a cam which is ro

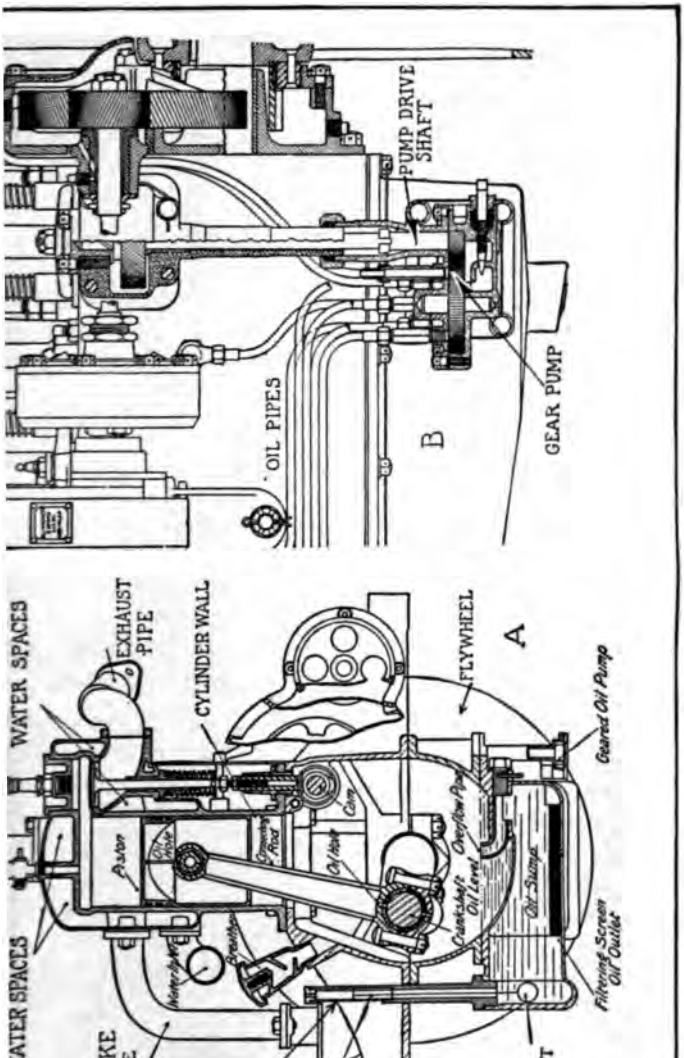


Fig. 212.—Sectional View of Engine, Showing Application of Constant Level Splash System at A. The Oiling System of the Franklin Automobile Shown at B.

by worm gearing. When the pump plunger is lifted by the can the inlet check valve opens and permits the pump cylinder to fill On the down stroke the outlet check valve opens and the oil flow through the sight feed fitting, from which it is directed to th bearing points through separate oil pipes, as shown in the systen outlined at B, Fig. 211.

A pump of the geared form is shown at C. This operates o exactly the same principle as the water pump of the same pattern previously described. A feature is the use of a relief check valv which will permit the oil to by-pass back into the intake portio of the pump when the pump is turning at such high speed tha surplus oil at higher than normal pressure is being supplied. Th view at D shows the application of the mechanical oiler show at Fig. 213, E. This is somewhat similar in principle to tha shown at B, except that it is simpler in construction. Mechanica lubricators of this form are used on some 1911 and 1912 model of the Overland car. The pump plunger is actuated by a yoke shaped member, the horizontal section of which rests on a cam The camshaft is turned by mechanical connection with the engine and as it rotates it lifts the yoke and the plunger attached to i against the resistance of a yoke returning spring. When the plun ger reaches the top of its stroke, oil will feed into the pump cyl inder through the two openings which communicate with the in terior of the lubricator. These openings are automatically shut of as soon as the pump plunger starts to descend. An exhaust checl plunger opens when the pump plunger descends, and permits th oil to flow past it through the feed tube to the motor. The amoun of oil displaced by the plunger depends upon its effective stroke An adjustment nut is provided which permits one to vary th amount the plunger will descend in the pump cylinder, though i will always rise to the same height as determined by the can profile. This type of oiler is very satisfactory, and will give but little trouble if clean lubricant is used. Foreign material or wa in the oil will have a tendency to clog the feed tube, but if thi should occur it will be indicated by the plunger remainin up. The plunger moves up slowly but drops faster, becaus *of the action* of the yoke spring. It is desirable to have th

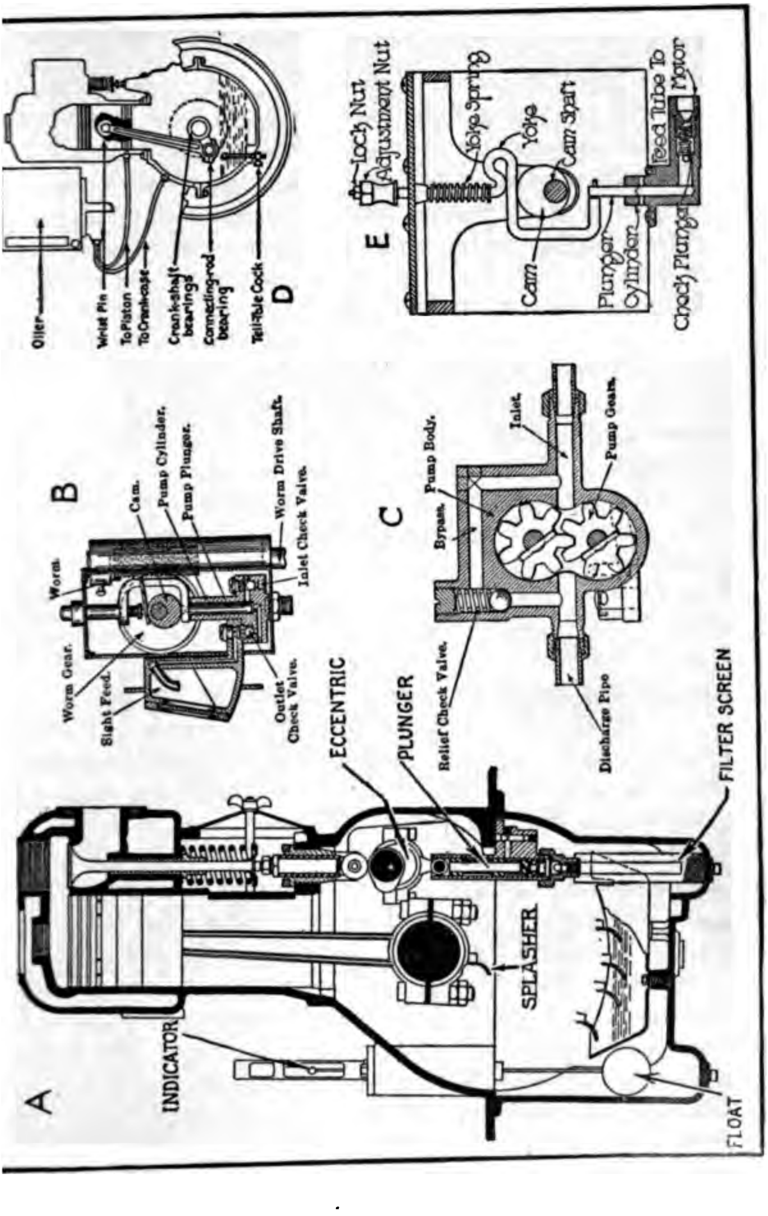
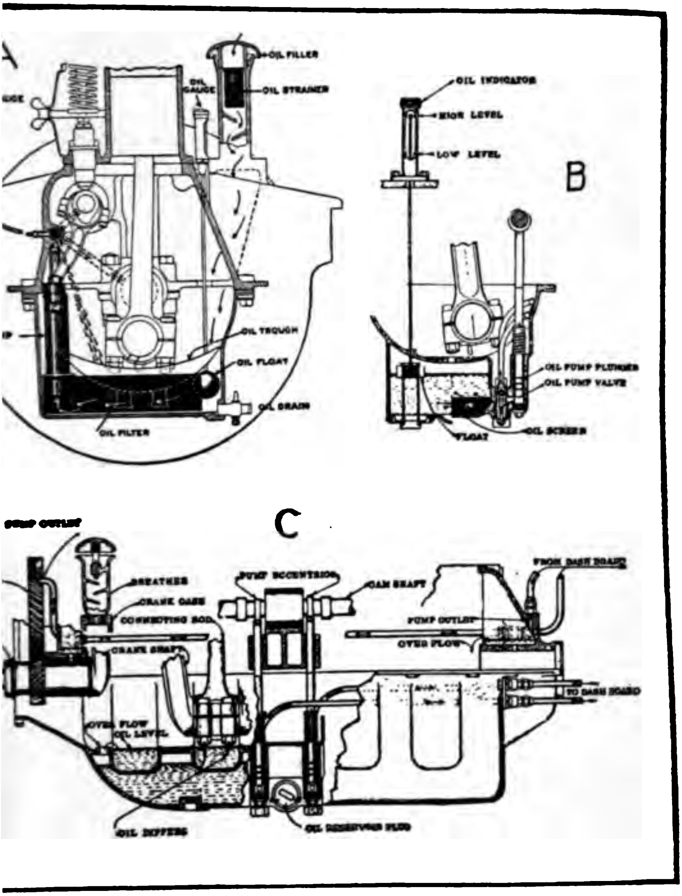


Fig. 213.—Various Forms of Oil Pumps Used to Circulate Lubricating Oil.

plunger come down suddenly, as more force is given to the discharge.

The lubricating system shown at Fig. 214, A, is that emplo on the Jeffery four-cylinder motor. As is true of all cons level splash systems, the oil container is integral with the bot of the crankcase, the oil is drawn from that part by the plu oil pump actuated by the camshaft eccentric, which forces the lu cant through a duct in the crankcase upper portion from which directed to camshaft bearings, main bearings and oil troughs which the connecting rods dip when they reach the lower par their revolution. The circulation of oil is indicated by a g on the dash indicating the pressure. The amount of oil avail in the sump or container is indicated by an oil level gauge w is actuated by a float raised and lowered as the supply incr or diminishes. When it is necessary to supply new oil, th inserted through the breather pipe on the side of the crankca

The system used on Abbott-Detroit motor cars is practi the same as that used on the Jeffery except that two oil pu are used. The view at B is an end sectional diagram show portion of the crankcase and sump. The general arrangeme the entire lubricating system may be clearly ascertained by ferring to the longitudinal view at Fig. 214, C. As is tru most systems of this nature, the supply of lubricant is replen through the breather pipe which is provided with integrally inclined vanes or ledges to prevent the crankcase compression ing out the oil mist. The level indicator or gauge is locat the right hand side of the engine, between the second and cylinders, and the proper level to maintain is between the and low points of the gauge. It is said that a point about below the high level mark indicated will give best results. the level at the proper height there will be about nine quarts in the reservoir, a point which must be considered when the lubricant is drained out and replaced by new. The sys classified as a constant level splash with positive plunger to circulate the lubricant. These two pumps are driven by trics on the camshaft, one pump supplying a constant str oil to the rear main bearing, the other pump feeding th



-Sectional View of Engine Base, Showing Jeffery Oiling System. d C — Views Showing Double Pump System on the Abbott it Car.

ing and timing gear compartment. The overflow from g drains into four separate troughs, into which the ends necting rods dip as they rotate. The lubricant is main- a constant level in this compartment by the use of over- from which any excess *lubricant* drains into the sump.

All lubricant drawn into the pumps is screened before it is allo to return to the bearings. The object of employing the separ troughs for the connecting rods to dip in is to prevent the oil fr flowing to the rear of the crankcase when the car is climbing hi or to the front of the crankcase when it is descending grades, either of these conditions would result in flooding one section the crankcase and depriving the other portion of an adequ supply of oil. It is recommended that every thousand miles the most the plug in the side of the lower half of the cra case be removed and all old lubricant drawn off. It is s gested that if the oil be examined carefully, and particles of me are found, this indicates bearing troubles. If the oil is fil with carbon particles it may be taken as an indication that leaks by the piston rings under pressure of the explosion burns away some of the oil on the cylinder walls. The scre used to filter the lubricant should be thoroughly cleaned bef replacing.

An oiling system similar to that just described, inasmuch as uses two pumps of the plunger type, is shown at Fig. 215. In t the oil reservoir is divided into three compartments; one of th serves as a main container for the oil, one at the center is fil part way up with water, while that at the front end is filled w oil, and also houses the circulating pump, and in this system pump furnishes oil to the main bearing at the rear, the other t similar member at the front, the crankshaft being a two-bea type. Passages are drilled in the crankshaft, through which oil goes to the lower connecting rod bearings. The oil thrown by the rotating crankshaft is splashed to all interior parts, lubricates the cylinders and pistons. Splash is not depended as a drain pipe at the bottom of the crankcase allows all the to escape from that member. The drain pipe communicates the bottom of the compartment partly filled with water. I claimed that the oil which must pass through the water be it will float on its surface is not only cleaned of all foreign ter, but that it is also cooled, an important requirement in speed motors. The oil floats on the top of the water and through a suitable overflow opening back into the main reser

is argued in favor of water as a filtering medium that it is not apt get clogged up with particles of carbon as a filtering screen is. sides, it has the added advantage of reducing the temperature the lubricant.

Overland Model 82 Oiling System.—The oiling system (Fig. 6) is automatic and self-contained. It is of the combination ree feed and splash type, in which a constant level is maintained the oiling base. It is very simple in operation and requires

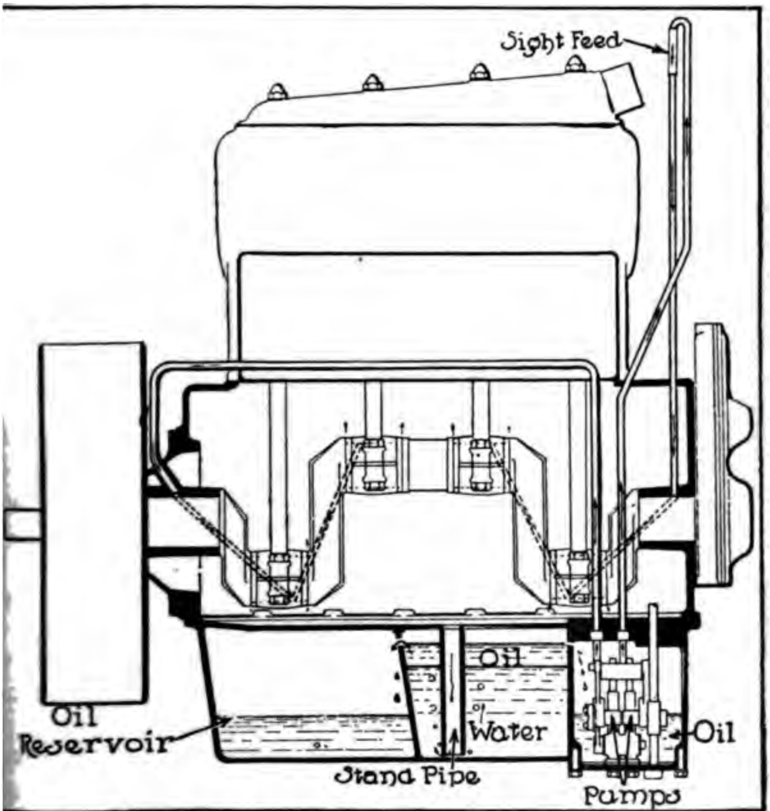


Fig. 215.—Double Pump System in Which Oil is Filtered Through Water to Remove Impurities.

no other attention than to see that the proper grade of supplied through the breather pipe when the oil indicator left side of the crankcase indicates that oil is needed. The of oil necessary to make the indicator register at the word is seven quarts, which is enough for from four to five h miles of ordinary running. The oil is circulated by a p

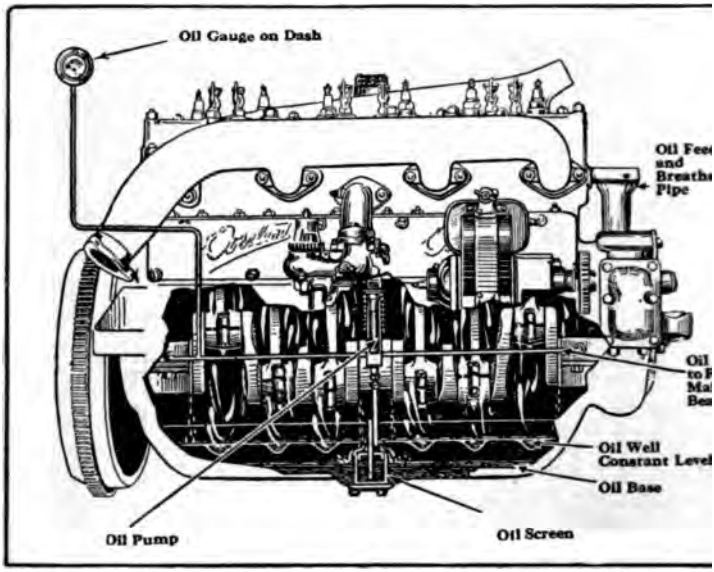


Fig. 216.—Overland Constant Level Oiling System.

pump located on the center rib of the cylinder block. The is operated by the camshaft.

The lubricant is drawn from the oil base through a fin screen, and forced direct to the three main bearings from it overflows to the oil pan. Six wells in the oil pan direct derneath the connecting rods are supplied with oil constantl a constant level is maintained at any motor speed and un conditions of road travel. The lower end of each connecti is supplied with an oil dip which scoops oil directly to the c *ing bearings* and splashes the lubricant on the piston wal

wrist pin bearings. The overflow from the front main beari flows to the front timing gear. From there it is carried by grav to all gears on the transverse shaft. It is very important tl the oil strainer be kept clean so that the circulation of the be insured. For this reason the removal of the oil strainer l been made easy. By loosening the four stud nuts on the bott of the crankcase the cylinder screen may be withdrawn and clean by dipping it in a pail of gasoline.

In replacing the screen it is well to shellac the gasket betwe the strainer flange and crankcase to make sure that the lubrica is properly retained. A drain plug is also provided in the bott of the crankcase for draining the lubricant. This should be dc once every thousand miles. The crankcase should then be wash out with kerosene into the breather pipe. After the kerosene l been removed replace the plug and refill the system by using t old lubricant, being careful to strain it through a fine grade muslin, and add fresh lubricant to make up the proper amount.

The proper working of the system is indicated by a pressu gauge located upon the instrument board of the cowl dash of t car in plain view of the driver. It is not necessary that t gauge indicate a given amount of pressure in pounds; it w be sufficient to notice the slightest detection of pressure by t needle moving to the right when the motor is accelerated. F motor lubrication use a light cylinder oil, free from carbon a having a flash-point of not lower than 425, and a fire-point of n less than 475 degrees Fahrenheit.

Another forced feed system in which no reliance is placed splash feed due to the connecting rods dipping the lubricant shown at Fig. 217. This is used on some Pierce-Arrow six-cylind motors, and includes a novel feature of having the oil suppli drawn from the oil container at the bottom of the crankcase an oil reservoir carried above the cylinders. While the oil is su plied to the reservoir by the pump it flows to the bearing points i dicated by gravity through oil supply tubes of large size. Bo the oil reservoir and the bottom of the crankcase are inclin twenty-five degrees, this inclination being given to the oil res voir when running up or down a grade, each lead will get

equal supply of oil. There are eight of these leads at the of the oil reservoir, one leading to the timing gear comp of the crankcase, the others to the main bearings of the shaft. The connecting rods are lubricated through suitable passageways in the crankshaft. As is true of other sys this nature, the interior of the engine base is filled with mist all the time that the engine is in operation, this ser

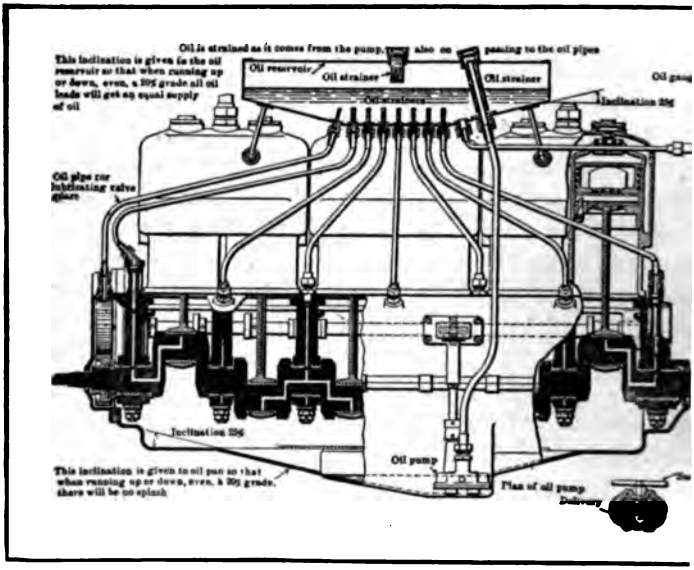


Fig. 217.—Oiling System Used on Many Early Pierce-Arrow M

lubricate the piston, cylinder walls, and valve operatin anism.

The simple pressure feed system used on the Nationa shown at Fig. 218. In this the bottom of the crankcase s a main reservoir for the lubricant. It is drawn from th geared oil pump driven by bevel gearing from the camsh discharge from the pump being piped to an indicator g the dash. The return from this indicator is directed to a *running the length* of the crankcase which supplies the o

ımpartments into which the connecting rods dip to splash the bricant about the crankcase interior. Attention is directed to ıe oil wells or pockets above the main bearings which catch part the oil distributed by the connecting rods and which feed it the main crankshaft bearings.

Another example of the system in which the oil is forced to ıe main bearings and from these members to the crankshaft inrior which is used on the Marmon motor, is shown at Fig. 219. his operates in the same manner as the Pierce-Arrow system out-

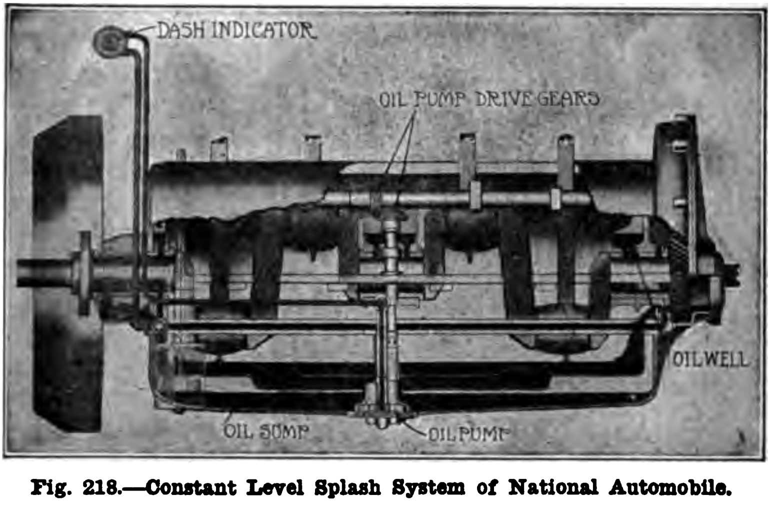


Fig. 218.—Constant Level Splash System of National Automobile.

ned at Fig. 217, except that all of the lubricant is carried in oil servoirs attached to the bottom of the crankcase. On some ıgines, especially of the Knight slide valve form, it is desirable increase the oil supply as the engine speed increases. This may easily done, as shown at Fig. 220, by providing swinging oil oughs operated by linkage which is interlocked with the carıretor throttle actuating lever. A top view of the system showıg the six oil troughs is given at A. At B the various positions the trough for high throttle, intermediate throttle, and low ırottle are clearly indicated by dotted lines. A side sectional iew at C shows the supply pipes used to fill the troughs, and

also shows the rod employed to tilt the trough. With th bers in the position indicated the connecting rod will more oil on account of the higher level. This positioı only on the highest motor speeds. On the intermediate s] as much oil is required as when the engine is running fa fore the troughs are tilted to a point where the oil lev(reduced. This system has the advantage of preventing

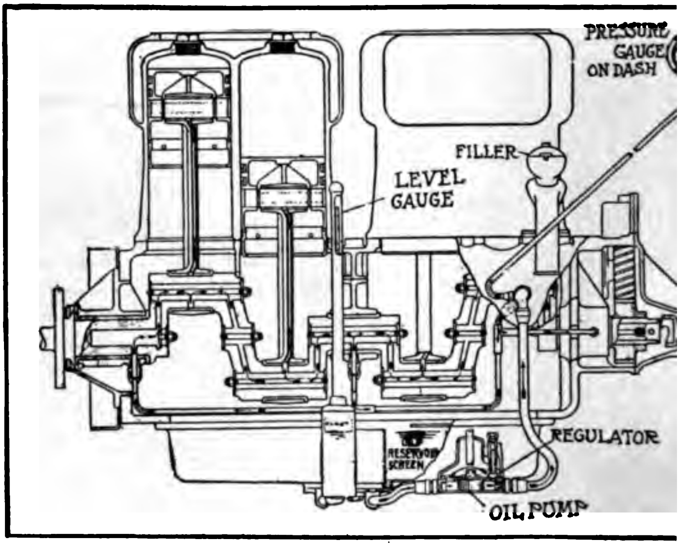
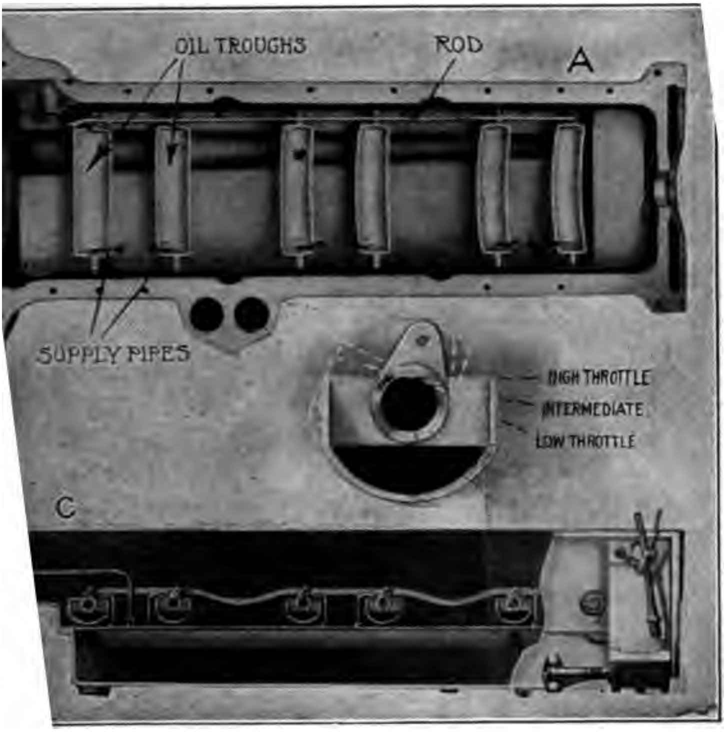


Fig. 219.—Pressure Feed Oiling System Used on Marmon Aut

due to burning too much oil, as in those systems where iı troughs are employed the level of oil in these members kept high enough to supply positive lubricity at high mot(Obviously, this amount of lubricant may be too much : engine speeds and the surplus lubricant will be discharge(the exhaust in the form of smoke.

The pressure feed system used on the Cadillac eight-c] motor is shown at Fig. 221. In this it will be observed oil is supplied to the three main bearings of the four-thr(*shaft by pipes* leading from a manifold running along the

and is also directed to the camshaft bearings through
r manifold. The connecting rod bearings are oiled throug
ges drilled in the crankshaft. The oil is circulated by
pump driven from the crankshaft by spiral gearing, the in
diate gear serving to drive the two water pumps, one a



How Tilting Troughs, Regulated by the Throttle Control, Vary the Oil Supply for Different Engine Speeds.

f the motor, by means of a cross shaft. An adjustable
lve is provided so that the oil pressure may be main-
ny desired point.

o Look for Trouble in Lubrication Systems.—But lit-
vill be experienced with the constant level splash sys-
h the oil is circulated by a positive pump through

passages cored in the motor base instead of long external
Considerable trouble is experienced on the old style cars hε
large number of individual leads running from a mechanic
or compression feed oiler to the various bearing points. The
sight feed lubricator employing compression pressure to ca
oil to circulate from the tank to the manifold fittings woul
cate a clogged pipe in a positive manner as the oil drip fee

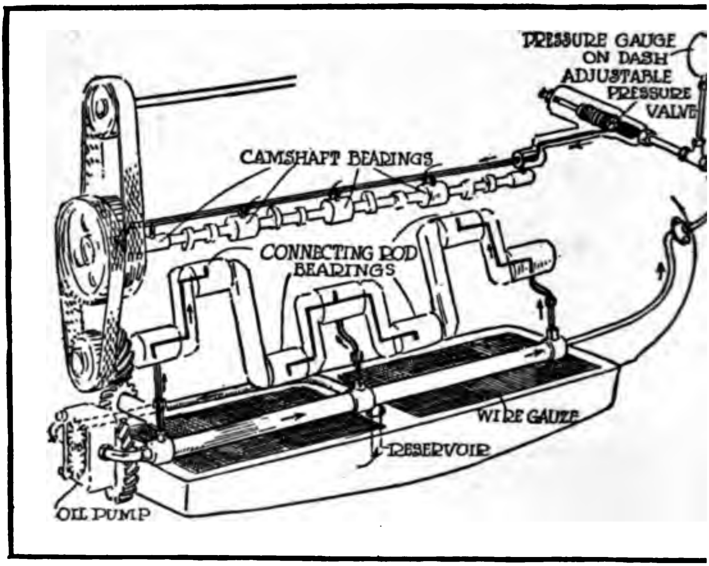


Fig. 221.—Oiling System of Cadillac 1915 Eight Cylinder Engi

would fill up if the pipe is constricted for any reason. I
of the failure of the oil to drop in the sight feed glasses w
adjustment screws are loosened to supply more lubrica
various pipe connections should be examined. The first
look at is the pressure pipe running to the tank. The firs
tial is to make sure that the tank filler cap seats secure
that the leather washer is interposed as packing under t
Disconnect the pipe next to the check valve and with the
running note if there is any pressure, i.e., if impulses fr

haust can be felt on the hand. If not, the nipple of the exhaust anifold or pipe should be removed and cleaned as it may be ioked with carbon, especially if considerable oil is fed to the iotor. The check valve near the tank may also be fouled up, ue to foreign matter. This should be taken apart and cleaned, eplaced, and the engine again started for testing the pressure. simple method of quickly locating the fault in a system of this ind is to disconnect the pressure pipe at the tank and blow hrough the check valve member. If the tank and oil pipe conections are tight the oil will flow through the sight feed glasses, nd it will be apparent that the trouble is due to not enough ressure being supplied the tank.

Leaks may exist between the sight feed glasses and their holders, nd this is usually denoted by leakage of the lubricant around ie bottom of the glass. In disassembling and readjusting this ember, care should be emphasized after new packing washers have en replaced, when readjusting not to screw down the fittings gainst the glasses too tightly as the glasses may be broken. When ie glass fills up with lubricant, which is a sure indication of a ogged feed pipe, that member should be removed and thoroughly eared by compressed air blast or steam under pressure. The eam is to be preferred as it will heat up any solidified wax or rease in the pipes. These sight feed glasses are apt to accumulate ust and dirt, especially as they are mounted in an exposed posion in order to note at a glance if oil is dropping properly. A iggestion is given at Fig. 222, A, for removing dirt when the arts are difficult of access with a cloth, which is especially true hen the sight feeds are assembled in a manifold fitting, as shown t B, where they are placed directly on the dash. A coarse, soft ring is used, a couple of turns being made around the glass, then y imparting a sawing motion to the ends of the cord the enrusted deposit will be easily removed.

In those lubricating systems having individual leads running rom a mechanical oiler, if failure of oil to reach the bearing is ot due to a broken or constricted feed tube the trouble must xist at the pump supplying that member. The common fault in lunger pumps is failure of the check valves to seat properly,

this being due generally to dirt in the oil. Of course, if th
driving means fails the pumps will not move and no oil
circulated. Oil pumps are not so apt to wear out as water

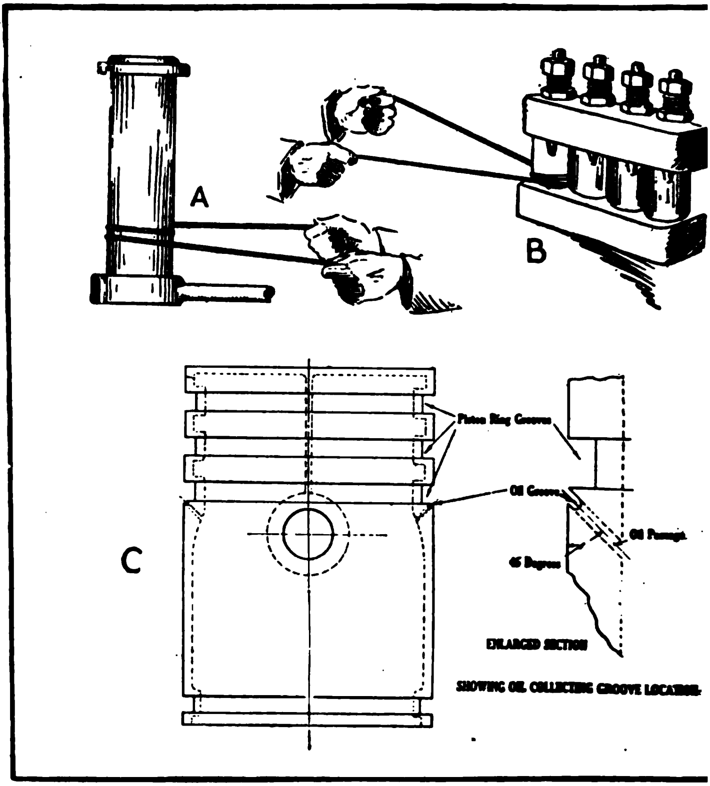


Fig. 222.—Showing Simple Method of Cleaning Sight Feed Ma Glasses at A and B. One Method of Curing Smoky Motor at C.

are on account of the lubricating properties of the oil, tends to minimize depreciation by keeping friction at a low

Method of Curing Smoky Motor.—The owner of a pra new car was much annoyed with a smoky exhaust which *indicated that* oil was working by the piston rings, and th

condition was evident even when the level of oil was below t
point recommended by the makers of the car if the motor w
run at high speeds. It was evident that the trouble was not d
to mechanical depreciation as the car was practically new. Aft
considerable study a cheap and successful remedy for the troul
was devised.

The cylinder head was removed, the connecting rod bearin
were loosened and the four pistons, after marking each, we
removed. Next the wristpins and connecting rods were taken c
and each piston, after taking out the two lowest piston rings, w
chucked up in the lathe separately. A small groove, a sixteenth
an inch in diameter, was cut into the piston, as shown in F
222, C, at an angle of 45 degrees. The cut started from the ed
of the bottom of the next to lowest piston ring groove. This c
was also one-sixteenth of an inch in depth, thus forming a cu
shaped groove the entire circumference of the piston. Next t
piston was drilled at the same angle of 45 degrees with a one-s
teenth inch drill. These holes, about one inch apart, were drill
clear through the piston. The effect of this groove was to collect t
oil backed up by the bottom piston ring on the downward strol
The small holes drained the oil into the inside of the piston a
thus back to the crankcase.

The rings were replaced, the wristpins and connecting rc
put back, the pistons slipped into the cylinders and the connecti
rods tightened up. Next the cylinder head was replaced and
put into the crankcase, the level of which was raised one-quart
inch above normal. When the motor was started the abnorm
amount of smoke which the little engine had formerly produc
failed to appear. After using his car a month, the owner call
at the garage to state that the job had proved satisfactory.
repair of this kind can be made only when there is sufficient w
thickness to the piston.

Simple Oil Filter.—There are many occasions when oil is dra
from a motor crankcase or sump when it still possesses lubricati
qualities, but is unsuitable for use owing to the presence of di
Even if an oil is unsuitable for cylinder lubrication, it may st
possess sufficient lubricating value to be used around the un

portant bearing-points of the car to which it can be appli
a hand oil can or syringe. Instead of throwing away the
possible to save quite a few gallons in the course of a year
simple filtering device as shown at Fig. 223 is used. Th
be made up by any tinsmith at small cost. It consists of
container of galvanized iron having a tight-fitting cover
will not get into it. Three ledges are soldered to the sides
tank as indicated, the one at the top holding a brass wir
screen, the two ones acting a ports for funnel discharge open each funnel is with clean wast by the time reaches the bot the container been thorough tered, the larg ticles of dirt be strained by th screen, while mainder is held waste plugs. cock is soldered

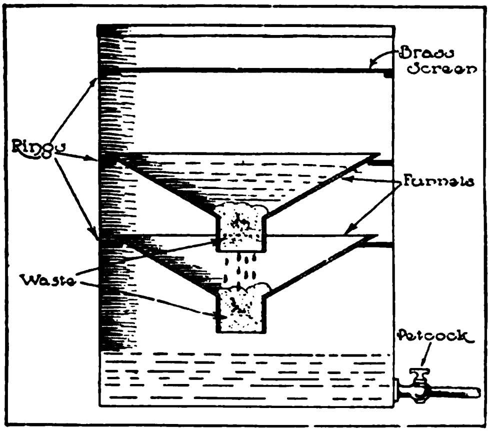


Fig. 223.—Easily Made Oil Filter for Garage Use.

bottom of the tank, so the filtered oil may be drawn out as

Requirements of Lubricating Oils.—Much difference of
exists relative to the best grade of lubricating oil to use
automobile power plant, some repairmen favoring the use of
light, free flowing oil, others recommend oils of medium
The best oil to use depends entirely upon the type of powe
and closeness of fit between the parts of the mechanism;
grade of oil is suitable for all engines. The following
from a paper read by Harry Tipper, an authority on lub
and lubrication, before the S. A. E., outlines the points i
in the selection of a suitable lubricating medium very clear
may be read with profit by all motorists and repairmen.

"Inasmuch as the arbitrary tests to determine the physi characteristics of the oil do not illuminate its value for any p ticular purpose, let us consider what the oil should do. In ord to bring this directly to the point of greatest interest to t society, that is, the lubrication of the motor of automobiles, me suggest the requirements which a lubricant for this purp should meet:

1. The oil should possess a sufficient body to keep the beari surfaces apart at the temperature at which the bearings run.
2. It should possess such qualities as will reduce the fricti to a minimum.
3. The flash point should be sufficiently high to insure agai the presence of volatile constituents.
4. It should remain fluid at such low temperatures as will met in service conditions.
5. It should have no tendency to decompose or to form su deposits as will gum up the machine and increase the frictio where the object is to decrease it.
6. It should contain no ingredients which will corrode or the metal.

"In considering the qualifications to be added to these gener requirements in order to define application to the mechanical co ditions of cylinder lubrication, it is necessary to consider the qu tions involved in the operation of an internal combustion engi which are different from those of any other type. What I ha to say now may appear very elementary from a mechanical star point, but unless it is mentioned, the important bearing which has upon lubrication will not be as obvious as I want to make After a charge has been taken into the cylinder on the sucti stroke it is compressed to from 50 to 75 pounds before being fir Naturally upon the starting of the compression stroke there is tendency for the gasoline mixture to leak. There are two wa of obviating this difficulty, of securing full compression. Th two ways might be stated as mechanically secured compressio formed by the close fit between the piston or piston rings and t cylinder wall; or compression secured by liquid seal, which mea the use of an easy clearing between the piston rings and t

cylinder wall and the sealing of the space between them by th use of a proper kind of lubricating oil. In respect to the me chanically secured compression the following points are wortl noting as axioms which must be taken into consideration in esti mating the conditions:

1. The closer the fit, that is, the less the clearance betwee the piston and cylinder walls, the more the power absorbed i turning the engine over. In fact, it is possible to secure perfec compression in this way only by securing so tight a fit that th mechanism will not turn. Even in practice good compression ca be secured only at the sacrifice of some of the effective power.

2. The closer the mechanical fit between piston and cylinde walls the thinner a lubricating oil which will work its way betwee them. The thinner the lubricating oil the greater will be th wear and tear, because of the impossibility of keeping the meta surfaces apart where the clearances are so small and the lubrican must be such a slight film.

"With these conditions, when wear and tear has once begun every stroke of the engine increases the loss of compression, th consumption of lubricating oil, the consumption of gasoline, i proportion to the amount of power, and, in fact, decreases con tinually the efficiency of the motor. You will readily see the im possibility of securing and maintaining maximum efficiency unde the conditions. The motor after leaving the factory is run at grea variations of speed and considerable variation of load. Thes variations are quite rapid and frequent. On account of the me chanical conditions of the motor you have recommended a ver thin, light lubricating oil for the motor, under the guarante This lubricating oil has no particular adhesiveness and will flo as readily from the cylinder wall as to it. Consequently, durin the rapid and frequent variations of speed, cylinder walls ar sometimes overburdened with oil and sometimes practically dry making wear and tear excessive and naturally resulting in a ver rapid increase in the space between the piston and cylinder wal This wear and tear is not thoroughly even; the clearance is large in some places than in others. Then the lubricating oil flows freel up and down the walls of the cylinder and there is never any tim

n just the proper amount of oil is on the cylinder wall. The is so thin that it cannot be held in the increased space, con- ıently on the compression stroke the gasoline mixture escapes ; the piston, destroying the lubricating oil in the crankcase, reducing from 15 to 30 per cent. the power which should be ıred from the gasoline. Further, the condition under discussion esponsible largely for the carbon which is so constantly being erienced on account of the fact that the oil, being very light ody and free-flowing, is drawn up during the suction stroke the compression chamber and onto the piston head, where it is illed, leaving a coke baked on the piston head to the first ring, n the valves, etc.

"Consider, instead of the mechanically secured compression used onnection with thin oil, compression which depends upon the of lubricating oil, the clearances being larger. From the stand- ıt of the mechanical efficiency of any power generator, and, in ;, any moving equipment, the best fit—that is, the mechanical which absorbs the least amount of power due to friction in the ver generator itself—is an easy sliding fit. If dependence is to aid, however, upon the metal and not upon the lubricating oil naintain compression, this easy sliding fit is too loose to give the ıpression required. If, however, it is intended to secure the ıpression by the liquid seal of the lubricant, then an easy ing fit can be given to the motor, a sufficiently heavy-bodied used for lubricating with the result that the metal surfaces be kept apart, the compression can be maintained so that ·e will be practically no change in the lubricating oil in the ıkcase, and only the ordinary wear and tear on a properly ·icated surface will take place, which wear and tear is infinitely ver than the wear and tear which usually occurs under the con- ons previously mentioned. In working out lubricating oils for omobile engines we are using to-day oil of 200, 300, 500 and viscosity; the oil of 200 seconds viscosity being used entirely those motors which are being made with clearances too small ermit of the oil of the proper body being used. Thousands of s by private owners, which, while they may not be accurate, cate the general result that in practice by the use of these

heavier oils they have secured from 10 per cent. to 20 p and in some cases over 30 per cent. more power from tl owing to the saving of any loss on the compression stroke. account they have also used less lubricating oil, due to t that there is no admixture of gasoline, deterioration conse being very slow. There is also less wear and tear on the cy and practically no trouble from carbon."

Peculiar Cause of Overheating.—A motorist who o very good make of car was bothered by a particularly sev of overheating, and was at a loss to find its true cause. Th was thoroughly overhauled to make sure that the lubricati tem was functioning properly, the interior of the waterjack cleared of all incrustation, the radiator replaced by one o capacity, the pump and water piping examined to insure t water circulation was brisk, the exhaust valves gone over t sure that they lifted enough to release the gases and th opened early enough, and all important members in the tr sion system were inspected to see that there was no bin harsh action at these points that would absorb power. Des the precautions taken, the car continued to overheat and the local repairman could do prevented the trouble. The was finally asked to give an opinion, and after the variou dies that had been applied ineffectually had been described tail, it seemed that but little had been overlooked, and t assumed that mysterious aspect that often puzzles even tl expert of repairmen.

The car was not fitted with a muffler cut-out valve a writer noticed that the muffler seemed particularly efficien gards silence, a barely perceptible sound being heard as was discharged in the air. As the overheating was accompa loss of power, and as the engine had very little power eve cooled it was assumed that the overheating was due to some tion of the mixture, but varying this till it was so thin t engine backfired through the carburetor did not improve the power or the chronic overheating. As an experime muffler was removed and the car operated with a direct e *The result* was a revelation, as the car not only had all the

one could reasonably expect, but there was not the slightest si of overheating.

It was then clearly evident that the muffler was at fault, so was taken apart and the interior carefully examined. The desi was such that it would have been a very effective silencer even normal condition, and the fact that cars of that make had a ve enviable reputation for silence kept all concerned from suspecti the muffler until nearly everything else had been tried. The pri ciple of action was to break up the gases before they reached t air by passing them through a number of baffle plates placed intervals in the muffler shell, these being perforated by a graduat series of holes to allow the gas to pass through. The first hol that is, those nearest the exhaust intake opening communicati with the engine were about 3/8 inch in diameter, but each su ceeding baffle plate had smaller openings but a greater numb so that the available discharge area was practically the same in the partition plates. In the member nearest the discharge end the muffler the holes were normally 1/8 inch in diameter.

The engine was fitted with a constant level splash system th insured copious lubrication and the owner had not spared the c The result was that accumulations of soot had filled the sm holes so that they were less than half their normal diameter a the back pressure resulting from this reduction of area had caus both the lost power and overheating. The holes were drilled out a larger size, 3/16 inch, so they would not be so liable to fill again, and after the muffler had been thoroughly cleaned so th all soot was removed from the entire series of baffle plate openin the component was replaced and the trouble ceased. Enlargi the holes produced a little freer discharge and the car was just trifle more noisy than it had been prior to the time the ho clogged up and caused defective engine action. Enlarging t openings was advisable, however, as they were not so liable clog up.

CHAPTER V

LOCATION AND REMEDY OF IGNITION FAULTS

Battery Ignition System Parts—Care and Wiring of Dry Cells—Storage Battery Defects—Storage Battery Charging and Maintenance—Ignition Timers—Spark Plugs—Induction Coil Faults—Adjusting Coil Vibrators—Low Tension Ignition System—Magnetic Spark Plug System—Wiring Troubles and Electrostatic Effects—Magneto Forms—Troubles with High Tension Magneto—Contact Breaker, Care and Adjustment—Recharging Weak Magnets—Transformer Coil Magneto System—Dual Magneto System—Master Vibrator Ignition Systems—Double and Triple Ignition Methods—Two Spark Ignition—Timing Battery Ignition Systems—Timing High Tension Magnetos—Firing Orders of Typical Engines.

THERE has been no part of the automobile that has been changed more often than the ignition system. The first cars had simple battery and coil ignition, then with the introduction of the high tension magneto the systems were usually combined on the same engine in order to secure double ignition systems, either one being independent of the other. Later, as the magneto became refined and improved, a number of makers discarded the battery ignition system and placed their entire reliance on the magneto. With the coming of the demand for electrical motor starting and lighting systems came a revival of the battery ignition method which had been discarded for the high tension magneto. The main reason for using the magneto in preference to the battery system was that ignition became weaker with the latter after the engine had been run for a time owing to a lessened output of the battery. The magneto which generates electricity by a mechanical process had the advantage because the faster it was driven the more current it delivered.

In the modern automobiles an electrical current generator is *provided, run by* the engine which is depended on to charge a

storage battery while the motor is running, the current for ig
tion and lighting being taken from the storage battery instead
directly from the generator which delivers a current of varyi
output depending upon the engine speed which in turn regula
the rate of generator armature rotation. On many cars therefo
the battery ignition systems are used as the use of the generat
keeps the battery charged always to the proper point for securi
energetic ignition. The automobile repairman will have cars
repair that will use a wide variety of ignition systems, as ma
of those fitted with the simple battery and coil are still in u
while a very large number are equipped solely with the high te
sion magneto. Most of the newer cars will use improved batte
ignition systems with the high tension magneto eliminated.

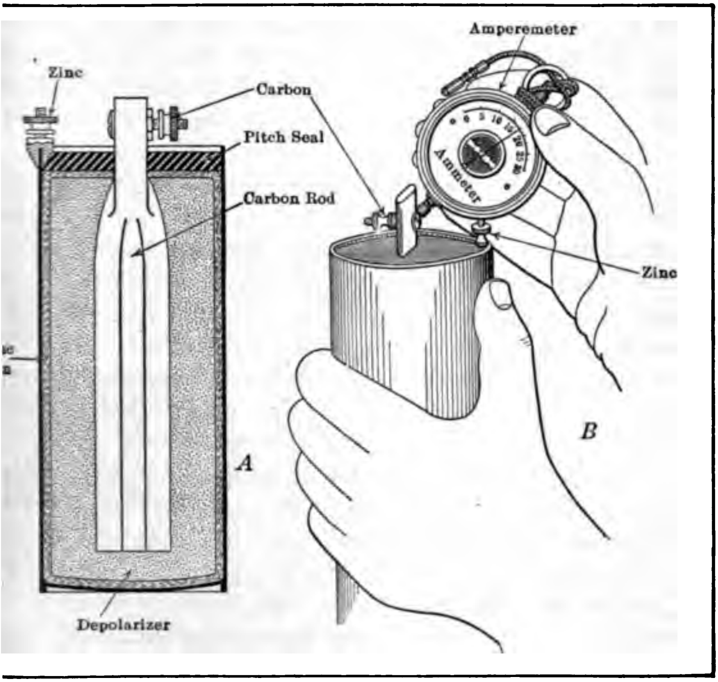
Battery Ignition System Parts.—A battery ignition system
its simplest form consists of a current producer, usually a set of d
cells or a storage battery, an induction coil to transform the low te
sion current to one having sufficient strength to jump the air gap
the spark plug, an igniter member placed in the combustion cha
ber and a timer or mechanical switch operated by the engine
that the circuit will be closed only when it is desired to have
spark take place in the cylinders. Battery ignition systems m
be of two forms, those in which the battery current is stepped
or intensified to enable it to jump an air gap between the poi
of the spark plug, these being called "high tension" systems a
the low tension form in which the battery current is not inte
sified to a great degree and a spark produced in the cylinder
the action of a mechanical circuit breaker in the combustion cha
ber. The low tension system is the simplest electrically but t
more complex mechanically. The high tension system has t
fewest moving parts but numerous electrical devices. At the pr
ent time practically all automobiles use high tension ignition s
tems, but as the repairman may have occasion to overhaul an "
timer" instructions are given for repairing the low tension ig
tion systems as well as the more popular forms. Low tension ig
tion methods are still used in marine engines, so a mechanic wo
ing on these types as well as automobiles should familiarize hims
with the principles of both high and low tension ignition syste

Ignition troubles are usually evidenced by irregular engine action. The motor will not run regularly nor will the explosions follow in even sequence. There may be one cylinder of a multiple cylinder motor that will not function at all, in which case the trouble is purely local, whereas if all the cylinders run irregularly there is some main condition outside of the engine itself that is causing the trouble. As complete instructions are given at the end of this chapter for a systematic search to locate troubles and as these may be readily identified by the symptoms described, it is not necessary to dwell on this point any longer, at the present time. In a battery ignition system the first point to be suspected in event of irregular ignition is lack of capacity in the current producer.

Care and Wiring of Dry Cells.—The simplest form of current producer is the dry cell which is shown in section at Fig. 224, A. A zinc can about 6 inches high and 2½ inches in diameter forms the negative element of the dry cell and also serves as a container for the electrolyte and positive element. A carbon rod placed in the center is insulated from contact with the zinc can by a seal of pitch which is a non-conductor of electricity and which also serves to retain the moisture in the cell. This carbon rod does not extend entirely to the bottom of the cup. The exciting fluid or electrolyte is a solution of sal ammoniac which is held against the negative element by blotting paper which is used as a lining for the zinc can. The space between this active lining and the carbon rod is filled with a depolarizing agent, usually black oxide of manganese, which is mixed with powdered gas retort carbon, the whole being saturated with exciting fluid in order to increase the electrical conductivity of the depolarizing mixture and also to keep the blotting paper lining properly moist. The depolarizor is necessary to enable the cell to be used continuously as it gives off oxygen to combine with the electrolyte after it has given up its chlorine to the zinc which leaves hydrogen to combine with the oxygen and form water. It will be observed that a dry cell is very simple in construction and that nothing is apt to occur that will reduce its capacity except diminution in the strength of the electrolyte or eating away of the zinc can by chemical action. The

ents in a dry cell are usually combined in such proportions about the time the electrolyte is exhausted, the zinc can will have outlived its usefulness. It is much cheaper to replace cells with new ones than to attempt to repair the exhausted

vaporation of the electrolyte is the main cause of deteriora- of dry cells as the internal resistance of the cell increases when

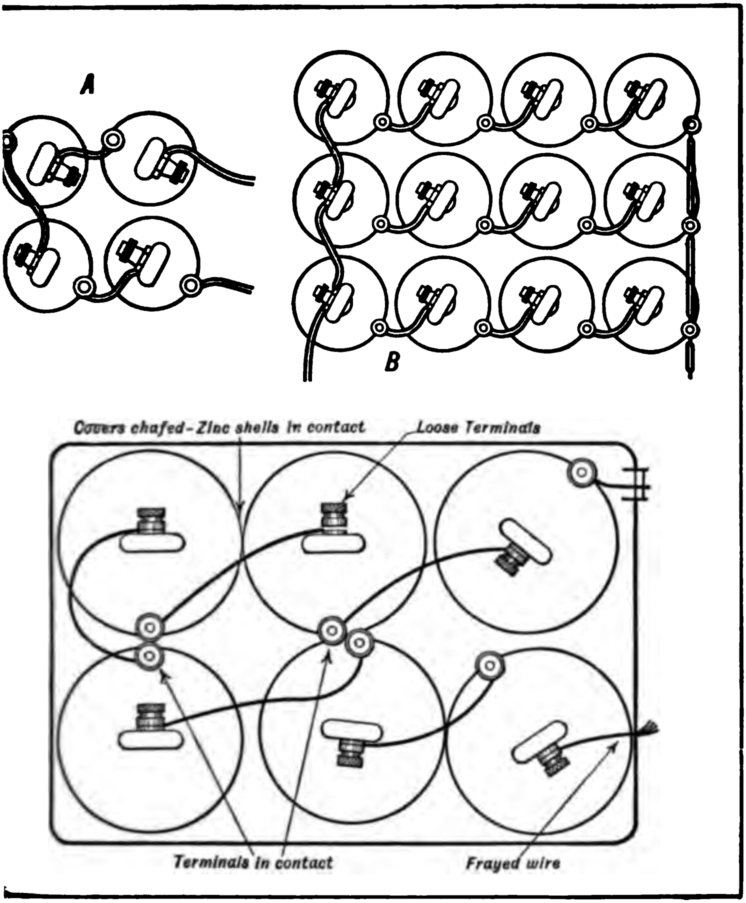


224.—View at A, Showing Internal Construction of Dry Cell Battery. B.—Method of Testing Dry Cell with Amperemeter.

oisture evaporates. It is said that dry cells will depreciate when not in use, so it is important for the repairman to buy only as needed and not to keep a large stock on hand. In to test the capacity of a dry cell an amperemeter is used as ted at Fig. 224, B. *Amperemeters* are made in a variety

of forms, some being combined with volt meters, as shown a Fig. 226. The combination instrument is the best form for th repairman to use as the volts scale can be employed for testing storage batteries while the amperemeter scale may be utilized ir determining the strength of dry cells. A fully charged, fresh dry cell should show a current output of from twenty to twenty-five amperes. If the cell indicates below six or seven amperes, it should be discarded as it is apt to be exhausted to such a point that it will not furnish current enough to insure energetic or reliable ignition. Dry cells should always be stored in a cool and dry place, so that the electrolyte will not evaporate. If moisture is given an opportunity to collect on the top of the pitch seal it will allow a gradual loss of current due to short circuiting the cells. In applying an amperemeter, care should be taken to always connect the positive terminal marked with a plus sign against the carbon terminal. In the indicating meter shown at B, it is necessary to use only one contact point which is pressed against the screw passing through the carbon rod. The case of the instrument is placed in contact with the zinc terminal to complete the circuit. A flexible wire is usually included in order to test the amperage of a group of cells should this be thought necessary. When dry cells are used for automobile ignition, they should be carefully packed in a box made of non-conducting material, such as wood, and securely covered so that there will be no chance for water to enter the container. If placed in a sheet metal case, care should be taken to line the box with insulating material and also to pack the cells tightly so they cannot shake around. The best practice is to use wedges or blocks of wood which are driven in between the cells to keep them apart. In no case should a dry cell be placed directly in a steel box, as the binding posts on the zincs might come in contact with the walls of the box and tend to short circuit the cells, producing rapid depreciation. A battery box should always be placed at a point where it is not apt to be drenched with water when the car is washed or should be watertight if exposed.

When dry cells are used for ignition there are two practical *methods of connecting* these up. At least four dry cells are neces-



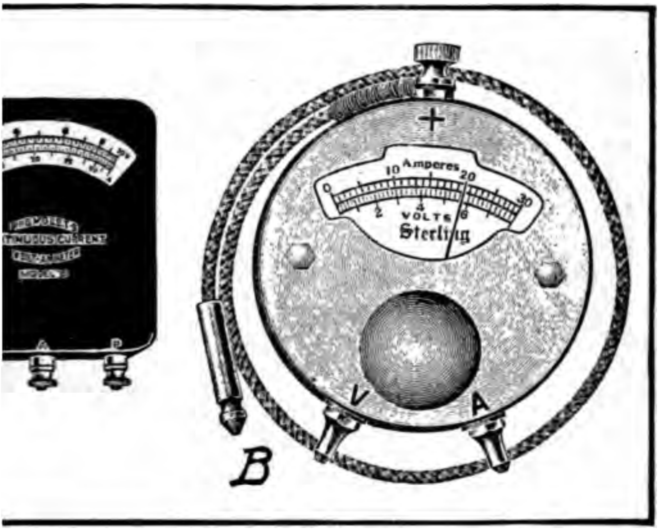
. 225.—Methods of Connecting Dry Cells and Precautions to be Observed When Wiring.

y to secure satisfactory ignition and much more energetic ex-
ions will be obtained if five or six are used. The common
hod is to join the cells together in series as shown at Fig.
A. When connecting in this manner the carbon terminal of
battery is always coupled to the zinc binding post of its
hbor. Connection would be made *from* the carbon of the first

cell to the zinc of the second, from the carbon of the second the zinc of the third, and from the carbon of the third to t zinc of the fourth, this leaving the zinc terminal on the first c and the carbon terminal on the fourth cell free to be joined the external circuit. When dry cells are connected in series t voltage is augmented, that of one cell being multiplied by t number so joined. The amperage remains the same as that one cell. If a dry cell has a potential of 1¼ volts, a battery com posed of four cells would show 5 volts. When dry batteries a used for lighting purposes or for igniting multiple cylinder e gines, in order to obtain better results, they are connected series multiple, as shown at B. Three sets of cells joined in seri are placed side by side with the free carbons at one end in and the zincs at the other also in line. The three carbo then joined together by one wire, the three zinc terminals other. When joined in this manner the battery has a voltag to that of four cells and an amperage equal to that of thre If a series connected battery as at A, indicates 5 volts amperes, the series multiple connection at B will indicate 5 and 60 amperes. When cells are joined in multiple the dr on any one cell is reduced and it is not so likely to become e hausted as when four are used in series. The points to be watch out for when installing dry batteries are clearly outlined at t bottom of Fig. 225. It will be seen that it is not desirable f terminals to come in contact with each other or with the sides the box nor is it conducive to good ignition to have the zinc sh in contact. A loose terminal on any one of the batteries will r sult in irregular ignition while a broken wire will interrupt altogether. If the insulation is frayed where a wire passes thro a hole in a metal battery box trouble may be experienced du short circuiting of the current between the bare wire and steel box, which may be grounded.

Storage Battery Defects.—The subject of storage bat maintenance was thoroughly covered in a paper read by H. Beck before the S. A. E. and published in the transaction the society. Some extracts from this are reproduced in con *tion with* notes made by the writer and with excerpts fro

ooks of battery manufacturers in order to enable the ecure a thorough grasp of this important subject with- ing a mass of literature. Endeavor has been made to e technical points involved and to make the exposition ; possible without slighting any essential points. In ; general adoption of motor starting and lighting sys- l modern automobiles, the repairman or motorist must



Two Forms of Combination Volt-Amperemeters for Garage Service.

attention to the electrical apparatus than formerly en the simple magneto ignition system was the only art of the automobile. The storage battery is one of mportant parts of the modern electrical systems and ate repairmen must understand its maintenance and ι order to care for cars of recent manufacture intelli-

ge battery, from an elementary standpoint, consists of re plates, positive and negative, insulated from each ubmerged in a jar of dilute sulphuric acid. The plates

consist of finely divided lead, known as the active material, h in grids which serve both as supports and as conductors for active material. The active material being finely divided, o an enormous surface to the electrolyte and thus electro-che action can take place easily and quickly. Two plates such scribed, would have no potential difference, the active mat each being the same. If, however, current from an outside is passed between them, one, the positive, will become oxi while the other remains as before, pure lead. This combi will be found to have a potential difference of about two v and if connected through an external circuit, current will f

During discharge, the oxidized plate loses its oxygen and plates will become sulphated until, if the discharge is carried enough, both plates will again become chemically alike, the ac material consisting of lead sulphate. On again charging, sulphate is driven out of both plates and the positive plate dized and this cycle can be repeated as often as desired until plates are worn out. Thus charging and discharging simply sult in a chemical change in the active material and electro and the potential difference between the plates and capacity due to this change.

In taking care of a storage battery, there are four po which are of the first importance:

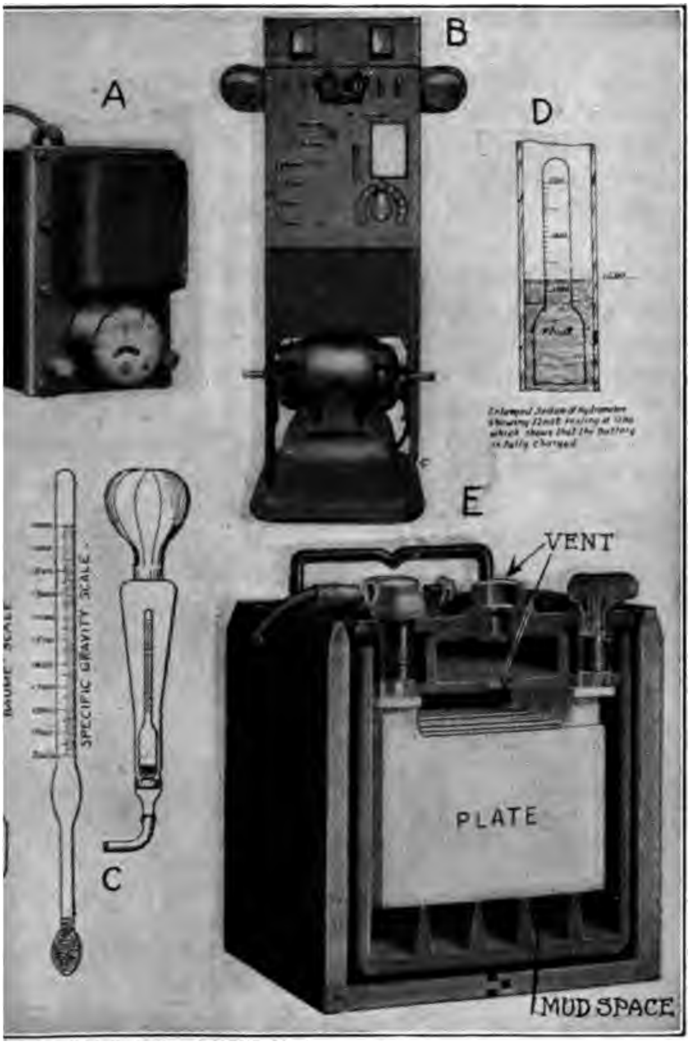
First—The battery must be charged properly.

Second—The battery must not be overdischarged.

Third—Short circuits between the plates or from sedi under them, must be prevented.

Fourth—The plates must be kept covered with electrolyte only water of the proper purity used for replacing evapora

In the event of electrical trouble which may be ascribe weak source of current, first test the battery, using a low re voltmeter. Small pocket voltmeters can be purchased for a dollars and will be found a great convenience. Cells may tested individually and as a battery. The proper time to a reading of a storage battery is immediately upon stopping while the engine is running. A more definite determination *be made than* after the battery has been idle for a few hours



—Devices Used in Charging and Caring for Storage Batteries.

has recuperated more or less. A single cell should register than two volts when fully charged, and the approximate en of a three-cell battery should be about 6.5 volts. If the vo is below this the batteries should be recharged and the sp gravity of the electrolyte brought up to the required point the liquid is very low in the cell new electrolyte should be ad To make this fluid add about one part of chemically pure phuric acid to about four parts of distilled water, and add water or acid to obtain the required specific gravity, whi determined by a hydrometer. According to some authoritie hydrometer test should show the specific gravity of the electr as about 1.208 or 25 degrees Baume when first prepared fo troduction in the cell, and about 1.306 or 34 degrees Baumé the cell is charged.

The following table gives the corresponding specific grav and Baumé degrees:

Baumé	Specific Gravity	Baumé	Specific Grav
0	1.000	18	1.141
1	1.006	19	1.150
2	1.014	20	1.160
3	1.021	21	1.169
4	1.028	22	1.178
5	1.035	23	1.188
6	1.043	24	1.198
7	1.050	25	1.208
8	1.058	26	1.218
9	1.066	27	1.228
10	1.074	28	1.239
11	1.082	29	1.250
12	1.090	30	1.260
13	1.098	31	1.271
14	1.106	32	1.283
15	1.115	33	1.294
16	1.124	34	1.306
17	1.132	35	1.318

The appended conversion formula and table of equiv *will be found* of value in changing the reading of a hydr

acidometer, from terms of specific gravity to the Baumé scale vice versa.

$$\text{Sp. Gr.} = \frac{145}{145 - \text{Baumé degrees}} \text{ at } 60° \text{ F.}$$

Either voltage or gravity readings alone could be used, but both have advantages in certain cases, and disadvantages in ers, it is advisable to use each for the purpose for which it best fitted, the one serving as a check on the other. Voltage the great disadvantage in that it is dependent upon the rate current flowing. Open circuit readings are of no value, as a reads almost the same discharged as it does charged. On the r hand, a voltmeter is a very easy instrument to read and be located wherever desirable. Specific gravity readings are st independent of the current flowing, but the hydrometer difficult to read, not very sensitive and the readings must be n directly at the cells.

Charging the Storage Battery.—Great care should be used charging and the charging rates given by the various manuturers should be followed whenever possible. It is essential t the positive wire carrying the charging current be connected h the positive plates of the battery. The positive pole of a is usually indicated by a plus sign or by the letter "P." In of doubt always ascertain the proper polarity of the termi- before charging. This is done by immersing the ends in ulated water, about an inch apart. The one around which more bubbles collect is the negative, and should be connected negative pole of the battery. If a cell is not connected prop- it will be ruined. A battery always should be charged, if ble, at a low charging rate, because it will overheat if ener- d too rapidly. The normal temperature is between 70 and degrees Fahrenheit. When the battery is fully charged the tion assumes a milky white appearance and bubbles of gas are rising to the surface of the electrolyte. All foreign matter d be kept out of the batteries as any metallic substance find- s way into the cell or between the terminals will short circuit ll and perhaps ruin it before its presence is known. The

terminals, the outside of the cell and all connections, shou kept free from acid or moisture. A neglect of these esse means corrosion and loss of capacity by leakage. There i point in connection with the charge which should be espe emphasized, namely, that the final voltage corresponding to a charge is not a fixed figure, but varies widely, depending the charging rate, the temperature, the strength of the electr and age of the battery. For this reason, charging to a fixed age is unreliable and likely to result disastrously. The cl should be continued until the voltage or gravity cease risin matter what actual figures are reached. Old cells at high tem tures may not go above 2.4 volts per cell, whereas if very they have been known to run up to three volts.

The points to be especially emphasized in connection wit charge are:

First—On regular charges keep the rates as low as pra and cut off the current promptly. It is preferable to cut little too soon rather than to run too long where there is question.

Second—Overcharges must be given at stated intervals continued to a complete maximum. They should be cut off a proper point, but when in doubt it is safer to run too long, r than to cut off too soon.

Third—Do not limit the charge by fixed voltage.

Fourth—Keep the temperature within safe limits.

Fifth—Keep naked flames away from cells while chargi the gas given off is inflammable. Always see that gas vent clear before charging.

The following table will undoubtedly be of value as a to the proper charging rates of batteries of various ampere capacities, the assumption being that these are all 3 cell bat that will show between 6.5 and 7.5 volts when fully ch While most manufacturers of batteries furnish instruction these may be lost, so some compact reference is needed. The dimensions of the batteries are given so the capacity may be mined even if the marks of identification on the name pla *obliterated.*

TABLE OF CHARGING RATES

Elba Lighting Batteries

Type.	Normal Charging Rates. Amp. Required.		24-Hr. Charging Rate	Volts per Cell at End of Charge at 24-Hr. Rate	Volts of Battery at End of Charge at 24-Hr. Rate	Size of Battery Over all		
	Start	Finish				Length in in.	Width in in.	Height in in.
ELB—60-90.......	9	3	3	2½	½	10⅜	7½	9½
ELB—80-120......	12	4	4	2½	7½	11½	7½	9½
ELB—100-150.....	15	5	5	2½	7½	12⅞	7½	9½
ELB—120-180.....	18	6	6	2½	7½	15⅜	7½	9½
HSB—60-90.......	9	3	3	2½	7½	9¾	6	10
HSB—80-120......	12	4	4	2½	7½	11	6	10¾
HSB—100-150.....	15	5	5	2½	7½	12⅜	6	10¾
HSB—120-180.....	18	6	6	2½	7½	15	6	10¾
PAB—120-180.....	18	6	6	2½	7½	10⅛	7½	14¼

A battery may be charged from any source of direct curre Garages, central stations, lighting plants, etc., can do the wo and in many instances where direct current is used for pow purposes, a simple charging outfit is operated from the dynan Where alternating current only is available, a rectifier whi changes alternating current to direct current may be installed a the battery charged with no inconvenience and at comparativ small cost. All of these methods will be considered in prop sequence and typical charging outfits described.

Remedies for Loss of Battery Capacity.—When a batte gives indication of lessened capacity it should be taken apart a the trouble located. If the cell is full of electrolyte it may of too low specific gravity. The plates may be sulphated, due lack of proper charge or too long discharge. The cells may ne cleaning, a condition indicated by short capacity and a tenden to overheat when charging. Sometimes a deposit of sediment

the bottom of the cell will short circuit the plates. If the sp gravity is low and the plates have a whitish appearance, t being little sediment in the cells, it is safe to assume that plates are sulphated. Sediment should be removed from the and the plates rinsed in rain or distilled water to remove part of dirt or other adhering matter.

The rate at which the sediment collects, depends largely u the way a battery is handled and it is, therefore, necessar determine this rate for each individual case. A cell should be out after say fifty charges, the depth of sediment measured the rate so obtained, used to determine the time when the bat will need cleaning. As there is apt to be some variation in amount of sediment in different cells, and as the sedimer thrown down more rapidly during the latter part of a period at the beginning, it is always advisable to allow at least fourth inch clearance. If the ribs in the bottom of the jars 1¾ inches high, figure on cleaning when the sediment reach depth of 1½ inches. Before dismantling a battery for "washi if practical, have it fully charged. Otherwise, if the plates badly sulphated, they are likely to throw down considerable ment on the charge after the cleaning is completed.

There have been many complaints of lack of capacity i batteries after washing. Almost without exception this is fo to be due to lack of a complete charge following the clea The plates are frequently in a sulphated condition when mantled and in any case are exposed to the air during the cl ing process, and thus lose more or less of their charge. W re-assembled, they consequently need a very complete charge, in some cases the equivalent of the initial charge, and unless charge is given, the cells will not show capacity and will give trouble again. This charge should be as complete as that scribed elsewhere in connection with the initial charge.

"Flushing" or replacing evaporation in cells with electr instead of water, is a most common mistake. The plates storage battery must always be kept covered with electrolyte, the evaporation must be replaced with pure water only. T *seems to be* a more or less general tendency to confuse the

trolyte of a storage battery with that of a primary cell. Th latter becomes weakened as the cell discharges and eventually re quires renewal. With the storage battery, however, this is nc the case, at least to anything like the same degree, and unless aci is actually lost through slopping or a broken jar, it should no

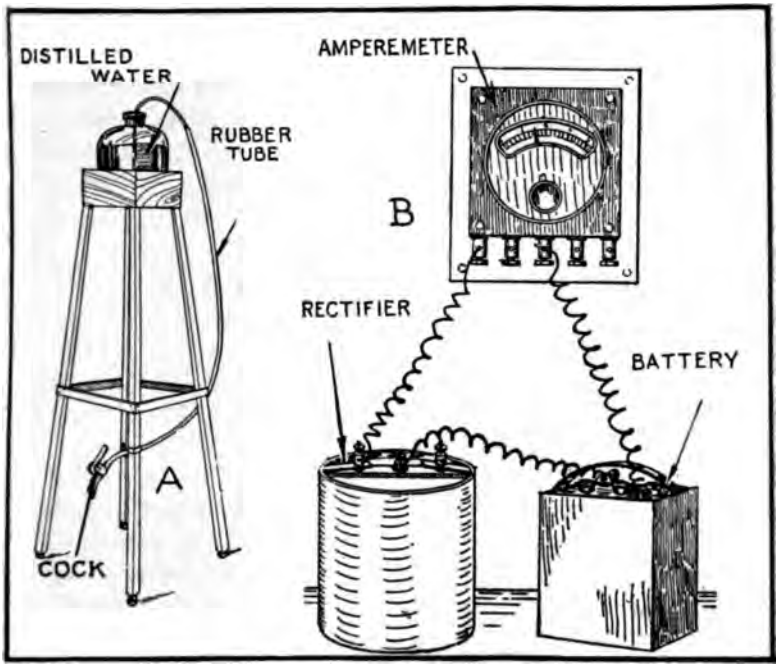


Fig. 228.—Simple Stand for Carrying Electrolyte or Distilled Water at A. Method of Using Rollinson Rectifier Shown at B.

be necessary to add anything but water to the cells between clean ings. Acid goes into the plates during discharge, but with prope charging it will all be driven out again so that there will be practi cally no loss in the specific gravity readings, or at least one s slight that it does not require adjustment between cleanings Thus, unless some of the electrolyte has actually been lost, if th specific gravity readings are low, it is an indication that some thing is wrong, but the *trouble* is not that the readings are low

but that something is causing them to be low, and the proper t to do is to remove the cause and not try to cover it up by do ing the indicator. The acid is in the cells and if it does not s in the readings, it must be in the form of sulphate, and the pr thing to do is to remove the cause of the sulphation if thei one, and then with proper charging, drive the acid out of plates and the specific gravity readings will then come back to proper point. The too-frequent practice in such cases is to electrolyte to the cells in order to bring up the readings, w as already explained, are only the indication of the trouble, this further aggravates the condition, until finally the plates come so sulphated that lack of capacity causes a complaint. ' practice of adding electrolyte to cells instead of water, seem be coming more and more common.

If there is any doubt about the polarity of the plates when assembling after cleaning it is well to note that the positive p is chocolate in color and the negative is gray.

When plates are sulphated, to restore them to their orig condition it is necessary that the battery be given a long, charge at about a quarter or a third of the normal charging r This should be continued until the electrolyte has reached proper specific gravity and the voltage has attained its maxim

It should be understood that sulphating is a normal as as an abnormal process in the charge and discharge of sto batteries, and the difference is in the degree, not the process. abnormal condition is that ordinarily referred to by the term. normal service sulphating does not reach the point where i difficult to reduce, but if carried too far, the condition become complete that it is difficult to reduce, and injury results. A v crude method of illustrating the different degrees of sulphatin to consider it as beginning in individual particles uniformly tributed throughout the active material. Each particle of sulp is then entirely surrounded by active material. The sulphate i is a non-conductor, but being surrounded by active material current can reach it from all sides and it is easily reduced. is normal sulphate. As the action goes further the partic *sulphate* become larger and join together and their outside

ducting surface is greatly reduced in comparison with their v ume so that it becomes increasingly difficult to reduce them a we have abnormal sulphate.

The general cure for sulphating is charging, so that a cell ha ing been mechanically restored, the electrical restoration consi simply in the proper charging. Sulphate reduces slowly and this account it is a good plan to use a rather low current ra High rates cause excessive gassing, heating and do not hasten t process appreciably, so that it is the safer as well as the mo efficient plan to go slowly. A good rate is about one-fifth norm The length of charge will depend upon the degree of sulphatin In one actual case it required three months' charging night a day to complete the operation, but this was, of course, an exce tional one. The aim should be to continue until careful volta and gravity readings show no further increase for at least t hours and an absolute maximum has been reached. In serio cases it may be advisable to even exceed this time in order make absolutely sure that all sulphate is reduced, and where the is any question it is much safer to charge too long, rather than risk cutting off too soon. A partial charge is only a tempora expedient, the cell still being sulphated will drop behind again.

Battery Charging Apparatus.—The apparatus to be used charging a storage battery depends upon the voltage and charact of the current available for that purpose. Where direct curre can be obtained the apparatus needed is very simple, consisti merely of some form of resistance device to regulate the ampera of the current allowed to flow through the battery. The intern resistance of a storage battery is very low and if it were coupl directly into a circuit without the interposition of additional r sistance an excessive amount of current would flow through t battery and injure the plates. When an alternating current used it is necessary to change this to a uni-directional flow befo it can be passed through the battery. Alternating current is th which flows first in one direction and immediately afterward the reverse direction. When used in charging storage batteri some form of rectifier is essential. The rectifier may be a simp form as shown at *Fig. 227, A*, which is intended to be coupled

rectly into a lighting circuit by screwing the plug attached to the flexible cord in the lamp socket. A rotary converter set such as shown at B, may also be used, in this the alternating current is depended on to run an electric motor which drives the armature of a direct current dynamo. The current to charge the battery is taken from the dynamo, as it is suitable for the purpose, whereas that flowing through the motor cannot be used directly.

The view at Fig. 227, C, shows a usual form of hydrometer-syringe which is introduced into the vent hole of the storage battery such as shown at E and enough electrolyte drawn out of the cell to determine its specific gravity. This is shown on the hydrometer scale as indicated in the enlarged section at D. A very useful appliance where considerable storage battery work is done is shown at Fig. 228, A. This is a stand of simple form designed to carry a carboy containing either acid, distilled water, or electrolyte. In fact, it might be desirable to have three of these stands, which are inexpensive, one for each of the liquids mentioned. In many repair shops the replenishing of storage batteries is done in a wasteful manner as the liquid is carried around in a bottle or old water pitcher and poured from that container into the battery, often without the use of a funnel. The chances of spilling are, of course, greater than if the liquids were carefully handled and more time than necessary is consumed in doing the work. The stand shown is about 5 feet high and is fitted with castors so it may be easily moved about the shop if necessary. For example, in taking care of electric vehicle batteries it may be easier to move the carboy to the battery than to remove the heavy battery from the automobile. The container for the liquid is placed on top of the stand and the liquid is conveyed from it by a rubber tube. The rubber tube is attached to a glass tube extending down nearly to the bottom of the liquid. At the bottom of the rubber tube an ordinary chemist's clip which controls the flow of liquid is placed. In order to start a flow of liquid it is necessary to blow into a bent glass vent tube which is also inserted into the stopper. Once the rubber tube has become filled with liquid merely opening the clip will allow the liquid to flow into the battery as desired.

In most communities the incandescent lighting circuit is used

for charging batteries on account of the voltage of the po\ circuits being too high. The incandescent lighting circuit may any one of six forms. A direct current of either 110 or 220 v(used over short distances, either 220 or 440 volts on three w circuits over long distances, alternating current at a const potential, usually 110 volts and in various polyphase systems. might be stated that in the majority of instances house and gar lighting circuits furnish direct current of 110 volts. We will c sider the devices used with the alternating form one of which shown at Fig. 228, B. This is known as the Rollinson electroly rectifier which is based upon the following principles: When element of aluminum and a corresponding element or plate of i are submerged in a solution of certain salts, using these eleme as negative and positive terminals, respectively, the passage of electric current through the solution produces a chemical act which forms hydroxide of aluminum. A film of hydroxide tl formed on the aluminum element repels the current. The arran ment of the cell will then permit current to pass through it in (direction only, the film of chemical preventing it from passing the opposite direction. The result is that if an alternating c rent is supplied to the cell a direct pulsating current can be tained from it. The outfits usually include a transformer reducing the line voltage to the lower voltages needed for batt charging purposes. Regulation of the current is effected in simplest type by immersing the elements more or less in the so tion in the jar. As complete instructions are furnished by manufacturers it will not be necessary to consider this form rectifier in detail.

One of the most commonly used rectifying means is the mercu arc bulb. This device is a large glass tube of peculiar shape, shown at Fig. 229, which contains in the base a quantity of m cury. On either side of this lower portion two arms of the gl bulbs extend outwardly, these being formed at their extremit into graphite terminals or anodes indicated as A and A-1. T current from the auto transformer is then attached one to ea side. The base forms the cathode or mercury terminal for negative wires. The theory of this action is somewhat complicat

but may be explained simply without going too much into c
The interior of the tube is in a condition of partial vacuum
while the mercury is in a state of excitation a vapor is sup
This condition can be kept up only as long as there is a cu
flowing toward the negative. If the direction of the curre

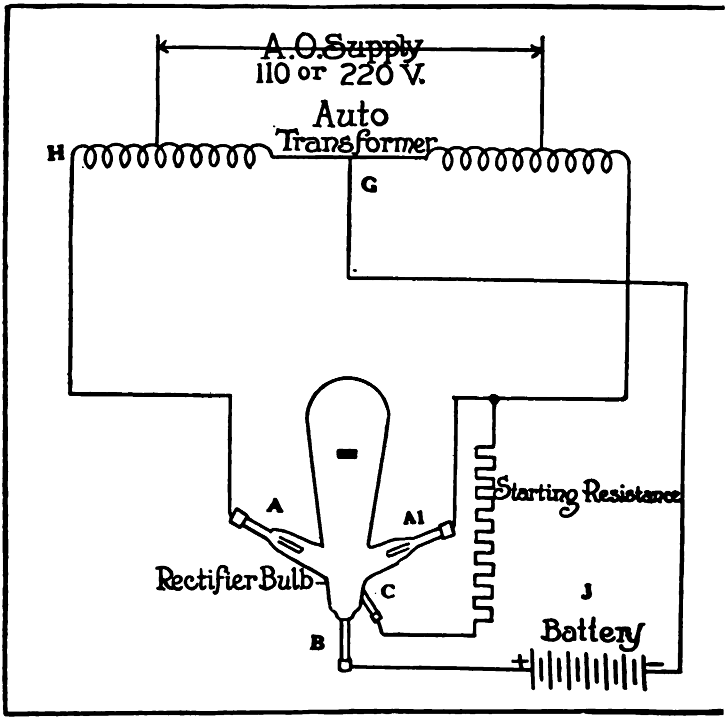


Fig. 229.—Wiring Diagram Defining Use of Mercury Arc Rectifie

reversed so that the formerly negative pole becomes a positiv
current ceases to flow, as in order to pass in the opposite d
tion it would require the formation of a new cathode ele
Therefore the flow is always toward one electrode which is
excited by it. A tube of this nature would cease to opera
alternating current voltage after half a cycle if some means

not provided to maintain a flow continuously toward the negati electrode. In the General Electric rectifier tube there are tv anodes and one cathode. Each of the former is connected to separate side of the alternating current supply and also throu reactances to one side of the load and the cathode to the othe As the current alternates, first one anode and then the other b comes positive and there is a continuous flow towards the mercu cathode thence through the load (in this case the battery to l charged) and back to the opposite side of the supply through reactance. At each reversal the latter discharges, thus maintaini the arc until the voltage reaches the value required to mainta the current against the counter E. M. F. and also reducing tl fluctuations in the direct current. In this way, a true continuo flow is obtained with very small loss in transformation.

A small electrode connected to one side of the alternating ci cuit is used for starting the arc. A slight tilting of the tube mak a mercury bridge between the terminal and draws an arc as so as the tube is turned to a vertical position. The ordinary for used for vehicle batteries has a maximum current capacity of amperes for charging the lead plate type and a larger form i tended for use with Edison batteries yields up to a limit of amperes. Those for charging ignition batteries will pass 5 ar peres for one to charge six cells and a larger one that will pa 10 amperes for from three to ten batteries. As is true of the electr lytic rectifier complete instructions are furnished by the man facturer for their use.

The Wagner device, which is shown at Fig. 227, A, operat on a new principle and comprises a small two coil transformer reduce the line voltage to a low figure; the rectifier proper whi consists of a vibrating armature in connection with an elect magnet and a resistance to limit the flow of the charging curre A meter is included as an integral part of the set for measuri the current flow. All sets are sold for use with ignition or ligh ing batteries of low voltage with a lamp socket plug and attac ing cord, the idea being to utilize an ordinary lighting circuit 110 volts A. C. The magnet and vibrating armature accompli the rectification of the current with little loss, the action af

connection to the battery which is to be charged proceeding automatically. By a simple device, the current stoppage throws the main contacts open so the partially charged battery cannot be rapidly discharged. While the rectifiers are constructed to use 60 cycle, 110 volt alternating current they will work at all frequencies from 57 to 63. The size made will pass three to five amperes, the voltage being sufficient to recharge a three cell battery.

When batteries are to be charged from a direct current it is possible to use a rheostat to regulate the voltage at the terminals. The construction of a rheostat is very simple as it consists only of a group of high resistance coils of wire mounted in insulating material and having suitable connections with segments on the base plate upon which is mounted the operating arm that makes the contact. According to the manner in which these are made and wired a large resistance is introduced at first, gradually decreasing as the lever is moved over or it may operate in the reverse fashion, a large amount of current being allowed to pass at the first contact and less as the handle progresses across the path. Rheostats should only be purchased after consulting a capable electrician as the required resistance must be figured out from the voltage of the circuit to be used, the maximum battery current, the charging rate in amperes and the number of cells to be charged at one time.

By far the simplest method of charging storage batteries is by interposing a lamp bank resistance instead of the rheostat. These are easily made by any garage mechanic and are very satisfactory for charging ignition or lighting batteries. Standard carbon lamps of the voltage of the circuit shown should be used and the amperes needed for charging can be controlled by varying the candle power and the number of lamps used. If the lamps are to operate on 110 volt circuit, a 16 candle power carbon filament lamp will permit one-half ampere to pass; a 32 candle power will allow 1 ampere to pass. If it is desired, therefore, to pass three amperes through the battery, one could use 3-32 candle power lamps or 6-16 candle power lamps. If the lamps are to burn on 220 volts it should be remembered that when the voltage is doubled the *amperage* is cut in half, therefore the 32 candle power, 220 volt

bon filament bulbs will only pass half an ampere. The method wiring is very simple as may be readily ascertained by re-ring to Fig. 230. The line wires are attached to a fuse block d then to a double knife switch. The switch and fuse block e usually mounted on a panel of insulating material such as ite or marble. One of the wires, the positive of the circuit, runs om the switch directly to the positive terminal of the storage

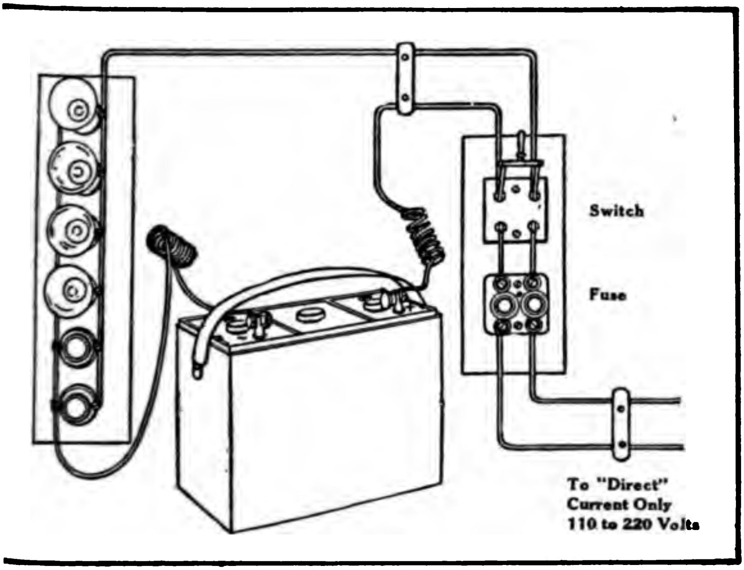


Fig. 230.—Charging Storage Battery from Direct Current.

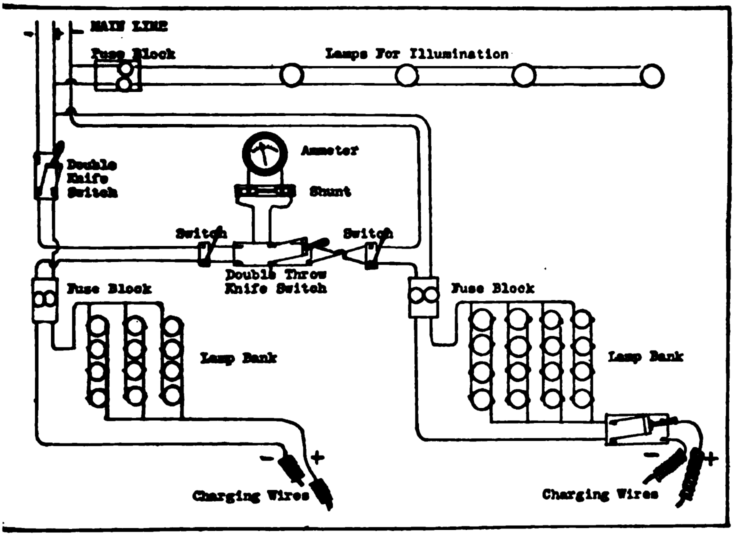
tery. The negative wire from the switch passes to the lamp k resistance. The lamps are placed in parallel connection with ect to each other but in series connection in respect to the ery. When coupled in this manner the current must overcome combined resistance of the storage battery which is very low that of the lamps. This prevents the battery being charged current of too high voltage.

. complete commercial installation which has been used suc-ully with a direct current of 110 volts pressure and which

has a capacity for charging 30-6 volt batteries simultaneously is composed of two charging sets either of which may be employed independently or both may be used at same time. The method of wiring is clearly shown at Fig. 231. In this a three wire system is employed for lighting. This consists of one positive wire and two negative conductors, forming in reality two separate circuits so that one half of the installation is on one wire, while the remainder is on the other two. An upper branch is used merely for illumination. On either half of the three wire double circuit is placed a bank of lamps, these being in series with the batteries but the lamps are in multiple with each other. The board at the left has 9 sockets, that at the right 12 sockets. The number of lamps placed in these and their candle power regulate the amount of current in amperes that will pass through the battery. As we have seen, battery manufacturers advise that certain minimum and maximum charging rates be used. Assuming that the maximum is 3 amperes, to pass a current of this value through the battery, it will be necessary to screw in 6-16 candle power lamps which will average 55 watts each, which means that at a pressure of 110 volts they require a current strength of half ampere. If fitted with 16 candle power lamps the 12 socket lamp bank will pass 6 amperes, and double this amount with lamps of twice the candle power.

The meter installation shown between the charging boards is to determine the amount of current passing through the storage battery and as it is a low reading instrument, a low resistance shunt is interposed so that any overload will pass over the shunt instead of through the instrument which is calibrated to measure currents up to 30 amperes. With the small single blade knife switches in circuit the current will not pass through the instrument, as it is not advisable to include this in the circuit permanently, because the passage of current through the windings may result in injurious heating. To get a reading from either side the single blade switch is thrown off and the double throw male member of switch is placed in contact between the blades on the side of which a reading is to be taken. It will be seen that the wires are crossed at the right of the two-way switch to cause the current to flow through the instrument in the right direction and also to have

negative terminal of each charging board at the left. This inates any confusion and the terminals are plainly marked it is not possible to make a mistake when coupling batteries. en more than one battery or set of cells is being charged they wired in series, the negative terminal of one battery being pled to the positive terminal of the neighboring one. In conting a battery to the charging board the negative wire should



. 231.—Wiring Diagram, Showing Installation for Charging Storage Battery from Direct Current, Using Lamp Bank Resistance.

ys be coupled to the negative terminal of the battery and the tive wire to the corresponding battery terminal.

eatures of the Edison Cell.—The instructions given apply to batteries of the lead plate type and not to the Edison bat- which is entirely different in construction. The Edison cell an electrolyte consisting of 21% solution of potash in distilled r so that the electrolyte is alkaline instead of acidulous. The ive plates consist of a series of perforated steel tubes which eavily nickel-plated and which are filled with alternate layers kel hydroxide and *pure metallic* nickel in very thin plates.

The tube is drawn from a perforated ribbon of steel, nickel-plated and has a spiral lapped seam. After being filled with active material it is reënforced with eight steel bands which prevent the tube expanding away from and breaking contact with its contents. The negative plate consists of a grid of cold rolled steel, also heavily nickel-plated, holding a number of rectangular pockets filled with powdered iron oxide. These pockets are also made up of finely perforated steel, nickel-plated. After the pockets are filled they are inserted in the grid and subjected to considerable pressure between dies which corrugate the surfaces of the pockets and forces them into positive contact with the grids. These elements are housed in a jar or container made from cold rolled steel which is thoroughly welded at the seams and heavily nickel-plated. The plates are assembled in positive and negative groups by means of threaded steel rods passing through holes in one corner of the plates and insulating washers. The terminal post is secured to the middle of the rod. The complete element or plate assembly stands on hard rubber bridges on the bottom of the can and is kept out of contact with the sides of the container by hard rubber spacers attached to the end. The can cover is also of sheet steel and contains fittings through which the electrodes pass, these being insulated from the cover by bushings of insulating material. A combined filling aperture and vent plug is secured to the center of the cover plate. For 6 volt ignition and lighting service it is necessary to use 5 cells owing to the lesser voltage of the Edison batteries. The average voltage during discharge is but 1.2 volts per cell and is not as constant as is the case with a lead battery, the voltage of which may be as high as 2.5 volts per cell.

An Edison 6.5 volt battery used for lighting or ignition may be charged completely in ten hours. A feature of the Edison battery is that overcharging at the normal rate has no harmful effects and it is advised by the maker to give the battery a 12 hour charge once every 60 days or when the electrolyte is replenished. The electrolyte must be kept sufficiently high so as to cover the plates and any loss by evaporation must be compensated for by the addition of distilled water. Another feature in which the Edison battery is superior to the lead plate type is that the

plates will not be injured if the cells are allowed to stand in a d charged condition. The external portions of the cells must kept clean and dry because the container or can is made of a co ducting material. The vent caps must be kept closed except wh replacing electrolyte or bringing the level up to the proper heig by adding distilled water. Care should be taken to avoid sh circuiting of the battery by tools or metal objects and special e phasis is laid on the precaution that no acid or electrolyte co taining acid be poured into the cells. It is said that the Edis battery has a longer life than the lead plate type of equal capaci

Winter Care of Storage Batteries.—It would not do simp to leave the battery in the car for a period of, say, 4 or 5 mon without giving it any care or attention, for in that case at t end of that time it would be found to have its plates so thicl covered with lead sulphate as to make it practically useless. F storage batteries "to rest is to rust" and become ruined, unl special precautions are taken. Automobile storage batteries a all or nearly all of the sealed-in type from which the elemen cannot be removed without a great deal of trouble. Therefo the only method of keeping the plates intact consists in chargi the battery at intervals of about two weeks. The following a vice concerning the care of batteries during a protracted peri of idleness of the car is due to the Willard Storage Battery C and refers especially to the batteries of starting and lighti systems.

At intervals of 2 weeks the engine should be run until t electrolyte shows a specific gravity of 1.280. If this is done reg larly the engine need be run only about an hour each time. B if the owner should not be in possession of an hydrometer, it better to run the engine for 2 or 3 hours each time, for the sa of safety. To charge the battery properly the engine should run at a speed corresponding to a car speed of about 20 mph the direct drive. There may be cases, however, where the own is compelled to store his car in a space where it is practically i possible to run the engine. Where this is the case, it is reco mended, if electric current is available, that the owner purcha a rectifier or small charging machine. A charge over night,

for about 12 hours, every 2 weeks with this apparatus will be sufficient to keep the battery in a healthy condition. Before beginning the charging the battery should be inspected to see if it is filled with solution. If the solution needs replenishing, distilled water should be added until the solution fully covers the plates which may be determined by removing the vent plugs and looking down into the cells. In case it is impossible to run the engine for charging and the owner does not care to incur the expense of purchasing a rectifier, he should remove the battery from the car and arrange for its storage at a garage which has charging facilities, stipulating that it must be charged every 2 weeks. The cost of having it so cared for will be nominal and will prove excellent insurance against deterioration.

To care for storage batteries of a type that is easily taken apart the following method is recommended: First charge the battery until every cell is in a state of complete charge. If there should be any short circuited cells they should be put into condition before the charge is commenced, so that they will receive the full benefit of the charge. Then remove the elements from the jars separating the positive from the negative groups, and place in water for about 1 hour to dissolve out any electrolyte adhering to the plates. Then withdraw the groups and allow them to drain and dry. The positives when dry are ready to be put away. If the negatives in drying become hot enough to steam, they should be rinsed or sprinkled again with clean water and then allowed to dry thoroughly. When dry, the negatives should be replaced in the electrolyte (of from 1.275 to 1.300 specific gravity), care being taken to immerse them completely and allow them to soak for 3 or 4 hours. Two groups may be placed in a jar and the jar filled with electrolyte. After rinsing and drying the plates are ready to be put away.

The rubber separators should be rinsed in water. Wood separators after having been in service, will not stand much handling and had better be thrown away. If it is thought worth while to keep them they must be immersed in water or weak electrolyte, and in reassembling the electrolyte must be put into the cells immediately, as wet wood separators must not stand exposed to the

air for any unnecessary moment, especially when in contact w plates. Storage batteries always should be stored in a dry pla preferably in one where the temperature will never fall below 4 Fahr. Storage battery solution or electrolyte varies greatly density between the points of complete charge and complete d charge. When completely discharged the electrolyte of the av age battery has a specific gravity of 1.14, and a sulphuric a solution of 1.14 specific gravity has a freezing point of about 1 Fahr. Therefore, if a completely discharged battery is allowed stand where it is exposed to extremely low temperature it is qu possible for the electrolyte to freeze and the cells to be injured consequence. However, as already pointed out, a battery for otl reasons must not be allowed to stand in the discharged conditi for any length of time. With increasing charge the density of t electrolyte increases until, when the charge is complete, it attai 1.28 specific gravity. The freezing temperature of the soluti drops very quickly as the specific gravity increases, somewhat follows:

Spec. Grav.	Freez. Point Degrees
1.14	+10
1.16	+ 5
1.175	— 4
1.20	—16
1.225	—36
1.25	—60
1.28	—85

Consequently there is no possibility of a storage battery bei injured by freezing in this latitude if it is kept in a fair state charge.

Timer Defects and Restoration.—In any high tension igniti system the primary circuit either of the battery or the magne must be interrupted at stated times in order to produce the spa necessary to ignite the gaseous charge at the instant of maximu compression or when the piston reaches the end of its up strol A timer is really a mechanically operated switch capable of tablishing a large number of contacts per minute without und depreciation. The timer shown at Fig. 232, is used on the Fo

motor and is the surviving type of numerous designs th
been made for this purpose. This device is sometimes
"commutator" and consists of an aluminum case circular
and having a projecting bushing or passage through wl
camshaft of the motor extends. The contact is establish
revolving arm which carries a roller that makes contact w

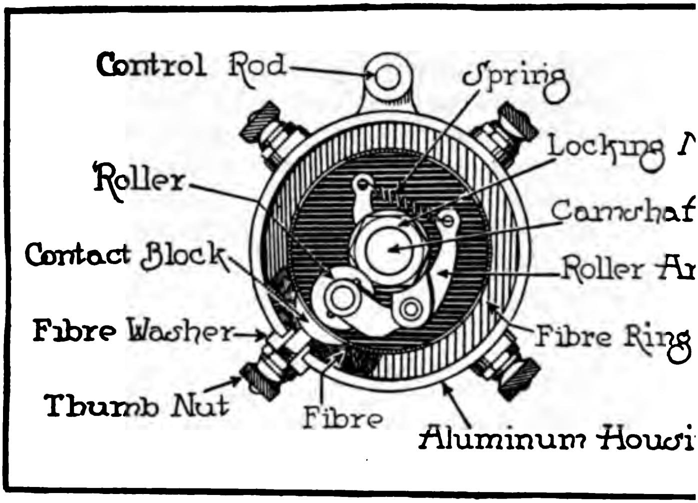


Fig. 232.—Timer Used on Ford Automobiles.

ments or blocks imbedded in a fibre ring which serves to
them from the metal parts of the timer.

The number of contact segments and their placing
upon the number of cylinders it is necessary to ignite. Or
cylinder motor four contact blocks are used, spaced 90
apart. For a two cylinder motor of the form ordinarily
to automobiles but two of the blocks would be used, sp
halves of the circle or 180 degrees apart. For a three
motor three contact segments would be needed, each se
from the other by a space of 120 degrees. On a six cylin
gine there would be one contact for each cylinder which
mean that the contact blocks would be separated by spac

egrees. The rotary portion of the timer usually revolves at cam-haft speed and should be timed in such a way that when the pis-on in cylinder No. 1 is at the top of its compression stroke the roller will be in contact with the segment that is connected to No. 1 spark coil by a wire. The arrangement of the remaining terminals depends upon the firing order of the motor. For instance, if it is 1, 2, 4, 3, the next terminal in the direction of roller arm rotation would be coupled to coil unit No. 2, that following to coil unit No. 4, and the remaining terminal to coil unit No. 3.

When a timer of this form is used, ignition is apt to be irregular should the spring attached to the free end of the roller arm break. If the interior of the device is filled with dirty oil, the current is apt to be short circuited. If the device has been oiled with a lubricant having too much body, the roller is not apt to make good contact with the metal segments and ignition will be erratic. Depreciation in the bearing pin on which the roller rotates or of the fulcrum pin on which the roller arm swings will also result in irregular ignition. If the motor runs steadily at low speeds but misses fire at high speeds, and the trouble has been traced to the timer, it is necessary to feel around the inside of he fiber ring with the finger to see that this is smooth and per-ectly round, and that the contact block faces are flush with the urface of the ring. If the blocks are worn below the surface of he ring, the roller is apt to jump the space at high speeds, due o the low block, and not establish an electrical contact. At low peeds the tension of the spring is sufficient to keep the roller earing against the contact blocks, as it will follow the irregular ontour of the timer interior without difficulty. If the segments re badly worn and the fiber ring roughened, the timer casing hould be chucked in a lathe or grinding machine and the interior round smooth and perfectly round with a small emery wheel. The writer has seen some mechanics attempt to take a light chip ut of the timer interior, as they were ignorant of the fact that he contact blocks were of tool steel and hardened. A fast-running, ree-cutting emery wheel is the best tool to use for smoothing lown hardened steel segments. The stem or bolt attached to the ontact block must pass through a fiber washer or bushing in

order that it be insulated from the timer body. If these b
crack, there may be an opportunity for leakage of curren
cially on the Ford car, where the ignition current is derive
the magneto and is stronger than that usually producec
chemical battery.

Another form of timer is shown at Fig. 233. In tl
contact is established between balls and a contact roller. I
to eliminate the wear that is unavoidable with plain bearing

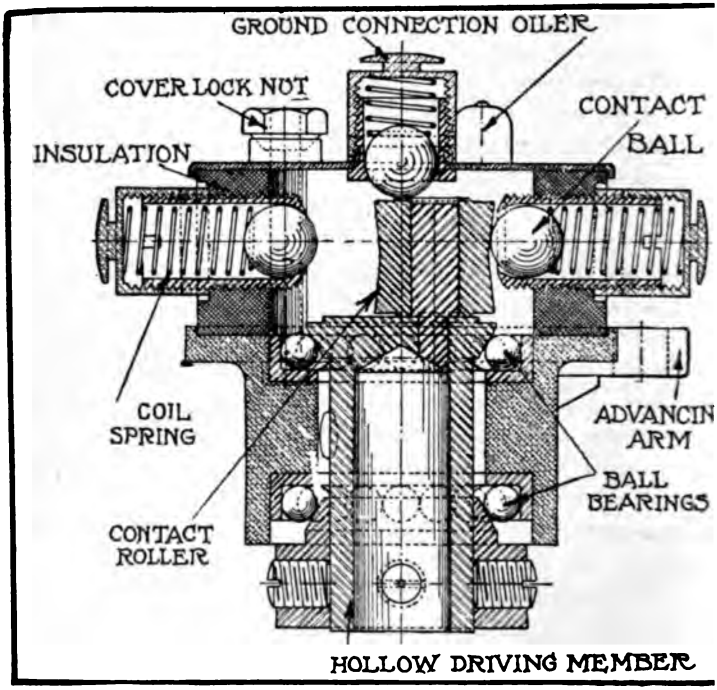


Fig. 233.—Showing Construction of Ball Contact Timer.

the casing carries ball bearings which are used to supp
central hollow revolving member. Some timers of the form
at Fig. 232 are fitted with a plain bearing which wear
the timer has been used and which produces irregular i
due to a poor ground contact. Battery timers of the forn

l are seldom used at the present time, as they have been suced by the more efficient short contact types. A notable excepto this almost general rule is the Ford car, which is manuured in immense quantities and which utilizes the roller contimer previously described.

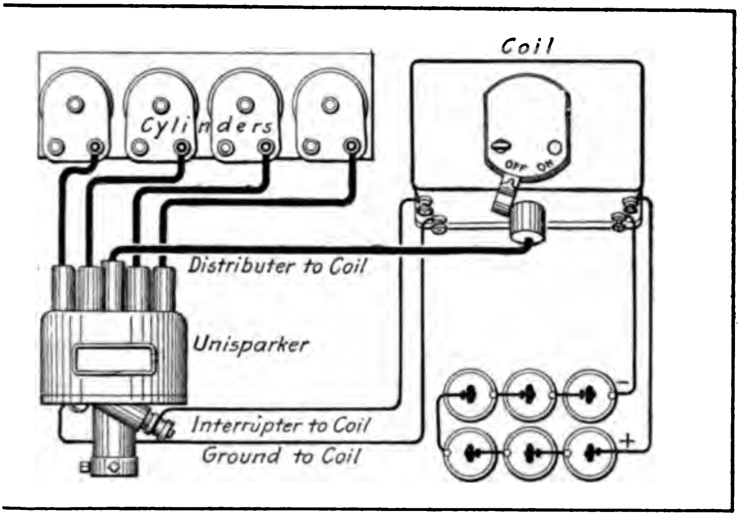


Fig. 234.—Atwater Kent Uni-Sparker System.

One of the best known of the short contact forms of timer is Atwater-Kent, which is usually combined with a secondary ributor as shown at Fig. 235. The method of placing this ing and distributing member in circuit is clearly shown in ing diagram Fig. 234. The advantage of a timer of the form wn, as contrasted to the simple type previously considered, is ; a one unit induction coil will serve any number of cylinders n 2 to 8, whereas with the roller type shown at Fig. 232 a ırate induction coil is needed for each cylinder to be fired. will be observed that the coil used with the Atwater-Kent em has five terminals, four of these being primary terminals, at the center of the coil box a secondary or high tension teral. A set of six dry cells connected in series is wired to one

side of the coil box as indicated. One of the two rema mary terminals runs to the primary contact at the bott interrupter, the other to a grounding screw attached to rupter casing. The secondary terminal is connected to t terminal of the distributor, while the remaining four are joined to the plugs in the engine cylinders in sucl to insure proper sequence of explosions. The externa

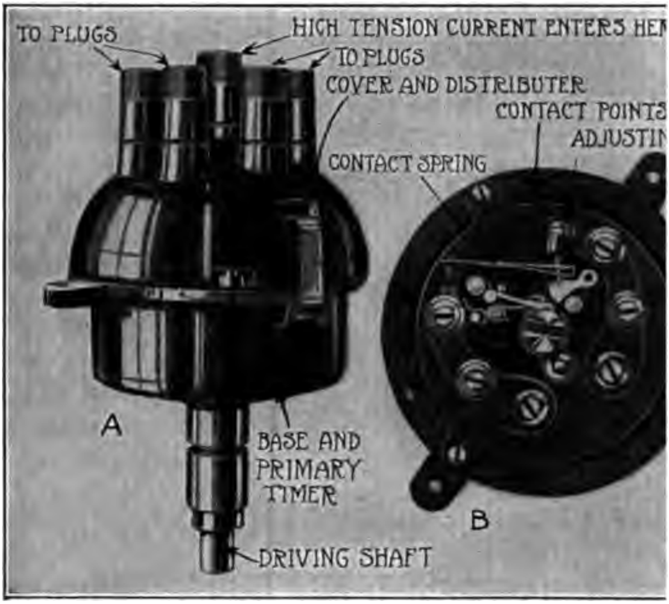


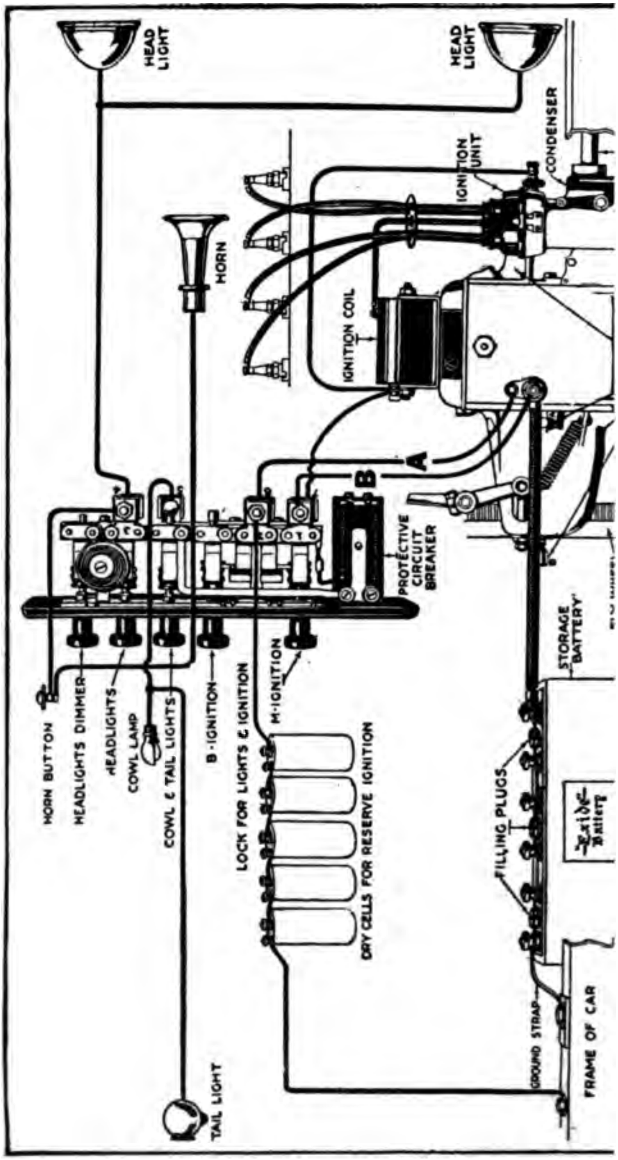
Fig. 235.—Showing Construction of Atwater Kent Uni-Sp

the Atwater-Kent uni-sparker is shown at Fig. 235, A a centrifugal mechanism is contained in the lower pa casing by which the spark is automatically advanced as of the engine increases.

The only points that will wear on a device of this cha the contact points which are clearly shown in the vi contact breaker mechanism at B. The revolving sha *center has* a number of notches, two, three, four, six,

according to the number of cylinders to be fired, cut into it. A light, hardened steel trigger is held against the shaft at this point by a small spring. On turning the shaft this trigger is carried forward by the notches in the shaft, and is suddenly released as the hook end leaves the notch. In so doing the back of the trigger strikes a small pivoted hammer situated between the trigger and the spring carrying the contact points. This causes the contact points to open and close with remarkable rapidity, but one contact being made for each spark. When it is desired to adjust the platinum contact points, as when they show signs of wear, it is only necessary to remove one or more of a number of extremely thin washers under the head of the adjustment screw and to replace the screw. The contact points should be absolutely clean and bright and have smooth contacting surfaces. The distributor portion of the device consists of a hard rubber block fitted to the top of the primary shaft, this carrying a brass quadrant that passes the high tension current to the spark plugs by means of the terminal points imbedded in the hemispherical cover. There is no actual contact between the rotating quadrant and the distributor points, as the high tension current is capable of jumping the very slight gap that exists between them. Owing to there being no actual contact, there will be no depreciation in the distributor or upper portion. The center terminal, which is in connection with the induction coil, is a combination of carbon and brass, and a light, flat spring on the quadrant bears against it to maintain positive electrical connection. The distributor cover is easily removed without the use of tools, as it is held by spring clips. Location or dowel pins in its lower edge insure that it will be replaced in the correct position.

One of the most popular of the combined starting, lighting and ignition systems is the Delco, which is shown at Fig. 236. For the present we will concern ourselves merely with discussing the ignition functions of the system, leaving the self-starting and electric lighting features for more comprehensive consideration in the following chapter. Current is produced by a one unit type motor-generator, although the windings of the device when operated as a motor or a generator are entirely separate. The ignition


HEAD LIGHT
HEAD LIGHT
HORN
IGNITION UNIT
CONDENSER
IGNITION COIL
A
B
PROTECTIVE CIRCUIT BREAKER
HORN BUTTON
HEADLIGHTS DIMMER
HEADLIGHTS
COWL LAMP
COWL & TAIL LIGHTS
B-IGNITION
LOCK FOR LIGHTS & IGNITION
M-IGNITION
DRY CELLS FOR RESERVE IGNITION
STORAGE BATTERY
FILLING PLUGS
Exide Battery
GROUND STRAP
FRAME OF CAR
TAIL LIGHT

current is obtained either from a storage battery which is kept in a state of charge by the generator, or from a set of dry cells which are carried for reserve ignition. The ignition system consists of a one unit non-vibrator coil, sometimes attached to the top of the motor generator, as shown at Fig. 236, though it may be placed at any convenient part of the car and a dual automatic distributor and timer usually included as a part of the device as shown. When ignition current is supplied from the lighting circuit the current passes from the storage battery through a switch and out to the low tension winding of the coil, from whence it passes to the timer and from there to the frame, where it is grounded. The high tension current generated in the coil runs to the distributor, where it is switched to the spark plug in the different cylinders in turn.

When dry cells are used for ignition the operation is the same except that a device called "the ignition relay," and shown at the right of Fig. 238, is added to the circuit. The function of this device is to break the circuit immediately after it has been completed by the contact points of the timer, which is shown at the left. The use of the ignition relay results in a material saving of the battery current as the circuit is closed a much shorter time than is the case when the circuit is broken by the timer contacts themselves. The operation of the relay is not difficult to understand. The magnet A attracts the armature B when the circuit is completed through the timer. This action opens contact C and breaks the timer circuit. A condenser D is mounted besides the magnet coil A, in order to absorb the current produced by self-induction in the magnet winding, which would be apt to produce a hot spark between the contact points when they were separated if no means were taken for its disposal. The adjustment of the relay is at the pole piece E. This regulates the distance between the armature B and the magnet pole, and the gap between the contacts C. The adjustment is made by turning the notched head at E clockwise to increase, anti-clockwise to decrease, the gap between the contacts. The correct distance between contacts C when the armature B is pressed down is equal to approximately the thickness of one sheet of newspaper. A very simple way in which

the adjustment can be made when the engine is running battery is to turn the notched head of the pole piece in the c clockwise direction until the motor ceases to fire. Then four or five notches in the opposite direction. Under no tions should the adjustment screw be turned very far in direction. If the armature vibrates feebly when the starti

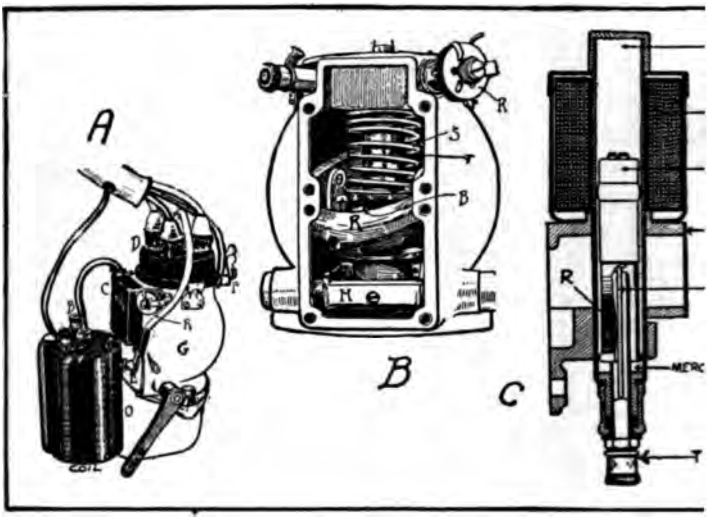
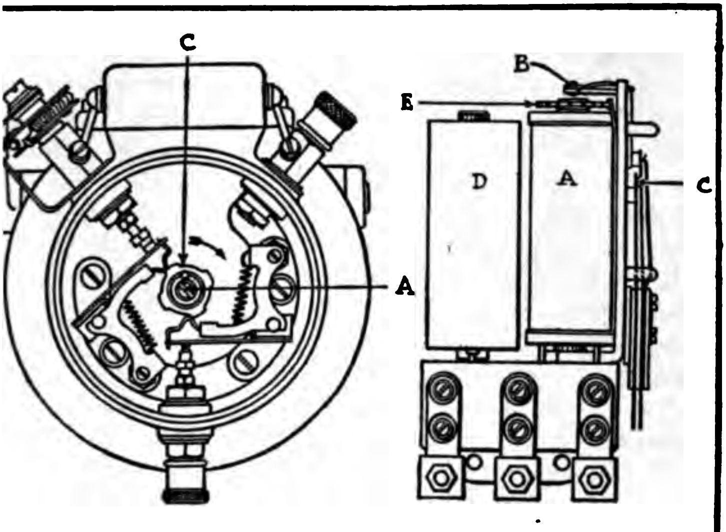


Fig. 237.—Some of the Regulating Devices Used with the Delco S

ton is pressed it indicates either weak dry cells or dirt l the relay or timer contacts.

The interior arrangement of a timer for both dry ce storage battery current is shown at Fig. 238. The ca driven by a rotating shaft and establishes contact betw points when the cam rider rises on the point of the cam. the cam rider drops into the notch between the high poi contact points separate. The same instructions that ha given for the contact points of the Atwater-Kent timer ap as well in this case. While the contact points are but on inch in diameter, it is said that many thousands of miles of may be obtained without readjusting. It is important t

:t spring, which is the straight one carrying the platinum should have a good tension outward against the cam rider er below it. It is said that this spring should be capable pporting the weight of half a pound. If the tension is not ently great the contact points barely break contact which its the spark to arc between them, tending to burn them.



238.—Short Contact Timer and Ignition Relay Used with the Delco System.

contact should be so adjusted that the contact spring is l away from the breaker member at least half the distance : T-slot on the vertical part of the cam rider, when the latter the contact lobe of the cam. The contact points should open ten one-thousandths (.010 inch) inch when the contact arm upon the back stop. The contact arm should clear the cam t at the contact lobe. A short wire connects the two posts breaker arms and this connection should always be inspected making adjustments to insure that it has not been disturbed. said that if this wire is disconnected the current will pass

through the contact spring, impairing its tension. Whenever th contact points are cleaned care should be taken to have the sur faces parallel.

In some of the Delco ignition systems an automatic spark ad vance mechanism is used. The usual method of wiring when th distributor is a separate member from the generator is shown a A, the left of Fig. 237. The construction of the automatic spark advance mechanism is shown at B. In this the shaft which trans mits motion to the timer is in the form of a tube T, revolved by spiral gears. An inclined slot is cut through the walls of this hol low driving member. A smaller shaft is carried inside of th hollow member, and a vertical slot is cut through this shaft ir order to permit a pin to pass through it, said pin being actuate by a collar adapted to slide up and down on the outside of th hollow driving shaft. The pin passes through both the straigh slot in the small shaft and the incline slot in the hollow driving member. If the collar holding the pin is moved it will change it angular relation with the small shaft which will advance the tim ing cam of the contact breaker. The collar is shifted by a spring loaded revolving ring R, which moves from the position shown in the drawing to a horizontal position as the speed increases. This ring is connected to the sliding collar and causes it to rise, ad vancing the spark as the engine speeds up or to fall, retarding the spark as the engine speed decreases. If desired, the spark timing may be controlled independently of the automatic advance mechanism by a spark lever connected to the corresponding mem ber on the steering wheel.

In some of the Delco systems a voltage regulator such as shown at C, Fig. 237, is used. The function of this device is to prevent too much current flowing to the storage battery when the engine is running at high speed. As the voltage of the storage battery will vary with its condition of charge the intensity of the magnetic pull exerted by the solenoid A upon the plunger C varies and causes a contact attached to the plunger to move in and out of the mercury which is contained in the bottom of the mercury tube B. When the battery is in a discharged condition the plunger C as sumes a low position in the mercury tube, and when in this posi-

ion the coil of resistance wire carried upon the lower portion is immersed in the mercury, and as the plunger rises the coil is withdrawn. As the plunger is withdrawn from the mercury more resistance is thrown into the circuit and the greater resistance causes the amount of current flowing to the battery to be gradually reduced as the battery nears the state of complete charge until finally the plunger is almost completely withdrawn from the mercury, throwing the entire length of the resistance coil into the shunt field circuit, thus causing an electrical balance between the battery and the generator and eliminating any possibility of overcharging the battery. A description of the voltage regulator follows: A solenoid coil A surrounds the upper half of a mercury-containing tube B. A plunger C, comprising an iron tube with a coil of resistance wire R wrapped around the lower portion on top of mica insulation, is adapted to be drawn up into the solenoid as the battery current increases in strength. One end of this resistance coil is attached to the lower end of the tube, the other end being connected to a rod B in the center of the plunger. The lower portion of the mercury tube is divided into two concentric wells by an insulating member, the plunger tube being partly immersed in the outer well and the rod in the inner well. The space in the mercury tube above the mercury is filled with a special oil, which serves to lubricate the plunger as well as protect the mercury from oxidation. The device is connected to the shunt field of the generator so that the current must follow a path leading into the outer well of mercury through the resistance coil R to the rods carried at the center of the plunger, from thence into the center well of mercury and out of the regulator. The more the resistance coil R is pulled out of the mercury the more resistance is interposed in the field circuit and a smaller amount of the generator current is going to charge the storage battery.

It will be noticed that in the wiring diagram shown at Fig. 236 a protective circuit breaker is attached to the switchboard. The function of this device is to open the circuit between the source of current supply (generator and storage battery) and the current consuming units (lamps, horn and ignition apparatus)

if one of the wires leading to a current consuming unit happ
to become grounded. Under such a condition an excessive fl
of current is possible on account of the lessened resistance of t
circuit. Such a flow goes through the winding of the circ
breaking relay or protected circuit breaker, which produces
magnetic pull that opens the contact and cuts off the cur
supply. As soon as the contact is opened the magnetic
ceases and the contact is closed again, re-establishing the mag
pull and again opening the contact. The circuit breaker
continue to vibrate until the ground or short circuit is lo
and corrected whenever any one of the switches controlling
current consuming units is pushed in to establish a circuit. T
function of this protective circuit breaker is the same as a f
block and fuse except that it is not necessary to keep replac
fuses.

Battery Ignition Systems.—Because of the almost univ
employment of electricity for lighting and starting systems,
battery ignition system has been improved materially inas
as the storage battery supplying the current is constantly cha
by a generator. A number of systems has been devised, t
operating on two different principles, the open circuit, such as
Atwater-Kent, previously described, and the closed circuit.
example of the closed circuit system is shown at C, Fig. 239,
is of Connecticut design, the complete ignition system con
of a combined timer and high tension distributor, a separ
duction coil and a switch. The system is distinctive in th
timer is so constructed that the primary circuit of the
permitted to become thoroughly saturated with electricity b
the points separate, with a result that a spark of maximu
tensity is produced. The action is very much the same as
of a magneto on account of the saturation of the winding.
other feature is the incorporation with the switch of a th
statically operated electro-magnetic device which automati
breaks the connection between the battery and the coil shoul
switch be left on with the motor idle.

The contact breaker mechanism consists of an arm A carr
one contact, a stationary block B carrying the other cont

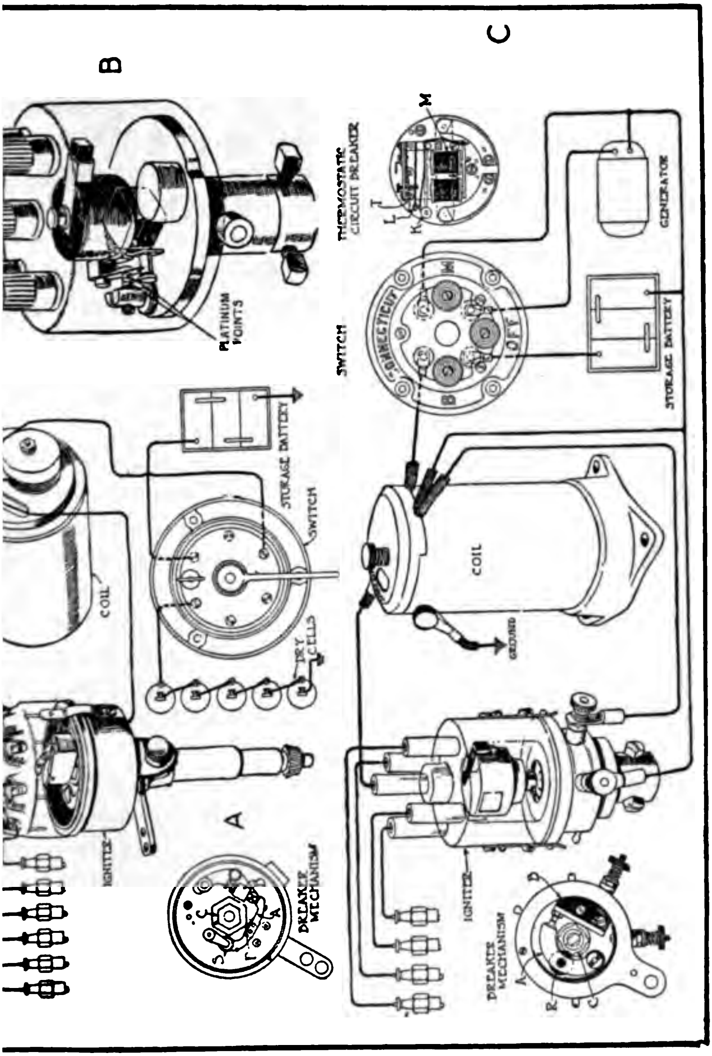


Fig. 239.—Typical Short Contact and Closed Circuit Battery Ignition Systems.

fiber roller R which is carried by the arm A and operated by points on the cam C, which is mounted on the driving shaft. Normally the contacts are held together under the action of a light spring. As the four cams, which in touching the roller R raise the arm and separate the contacts, are 90 degrees for a four-cylinder motor, the period of saturation of the coil or the length of time the current flows through it to the battery is sufficiently long so that when the points have separated the current which has "piled" up induces an intensely hot spark at the plugs. This is an advantage inasmuch as it insures prompt starting and regular ignition at low engine speed as well as providing positive ignition at high engine speed.

The thermostatic circuit breaking mechanism is very simple. This consists of the thermostat T, which heats when the current passes through it for from thirty seconds to four minutes without interruption, and thus is bent downward, making contact with the contact L. This completes an electrical circuit which energizes the magnets M, causing the arm K to operate like the clapper in an electric bell. This arm strikes against the plate, which releases whichever of the two buttons in the switch may be depressed.

As will be observed, the transformer coil provided has five terminals. One of these is connected directly with the ground, the other leads to the central secondary distributing brush of the timer-distributor. Of the three primary leads, one goes to the switch, one to the wire leading from the storage battery to the timer, and one directly to a terminal on the timer. The switch is provided with three buttons, the one marked B being depressed to start the engine, as the ignition current is then drawn from the storage battery. After the engine has been started the button marked M is pressed in, this taking the current directly from the generator. To interrupt ignition the button "off" is pressed in, this releasing whichever of the buttons, B or M, is depressed. Four wires run from the distributor section of the igniter to the spark plug.

The Remy system also operates on the closed circuit principle and is shown at A, Fig. 239, in a form adapted for six-cylinder engine ignition. The transformer coil is of the three terminal type

e secondary going to the central secondary distributing brush the timer while one primary is joined to the primary contact minal of the timer portion of the igniter. The remaining coil minal is joined to the switch. One of the poles of the storage ttery and one of the series of dry connected cell batteries are unded, while from the other two the wires run to the switch ntacts. The current may thus be derived either from the dry ll batteries for emergency or from the storage battery for regular nition purposes. The construction of the timer which incorrates the breaker mechanism is clearly shown. The movable tinum contact point is carried by the arm A, which fulcrums the bearing S, and which has a piece of hard steel F riveted it to act as a cam rider. The cam C is of hexagonal form, ving six points which separate the contacts when they ride r the shoe F attached to the arm A. The fixed platinum cont point B is so arranged that it may be adjusted by moving or out as conditions demand. It is to this member that the mary terminal of the coil is connected.

A typical combined timer distributor known as the Halladay shown at B, Fig. 239. The make and break mechanism is very ple in design, as is the distributing mechanism. The contact ween the platinum points is established by a four point cam. e secondary current is distributed from the central terminal to four distributing terminals by a carbon brush very much simi- in design to that employed in a high tension magneto. This rates on the open circuit principle.

Spark Plug Faults.—The part of the ignition system that is apt give the most trouble, and for the most part through no fault its own, is the spark plug which is placed in the combustion mber in order to permit a spark to take place between the ctrodes whenever it is necessary to explode a charge of gas. rk plugs are made in infinite variety, some representative sim- forms being shown at Fig. 240. Those in section at A, B and utilize a porcelain insulator through which a central rod or trode passes. This terminates at the top in a threaded mem- , to which the thumb nut is screwed. In most plugs using lain insulators a cap is cemented to the top of the porcelain

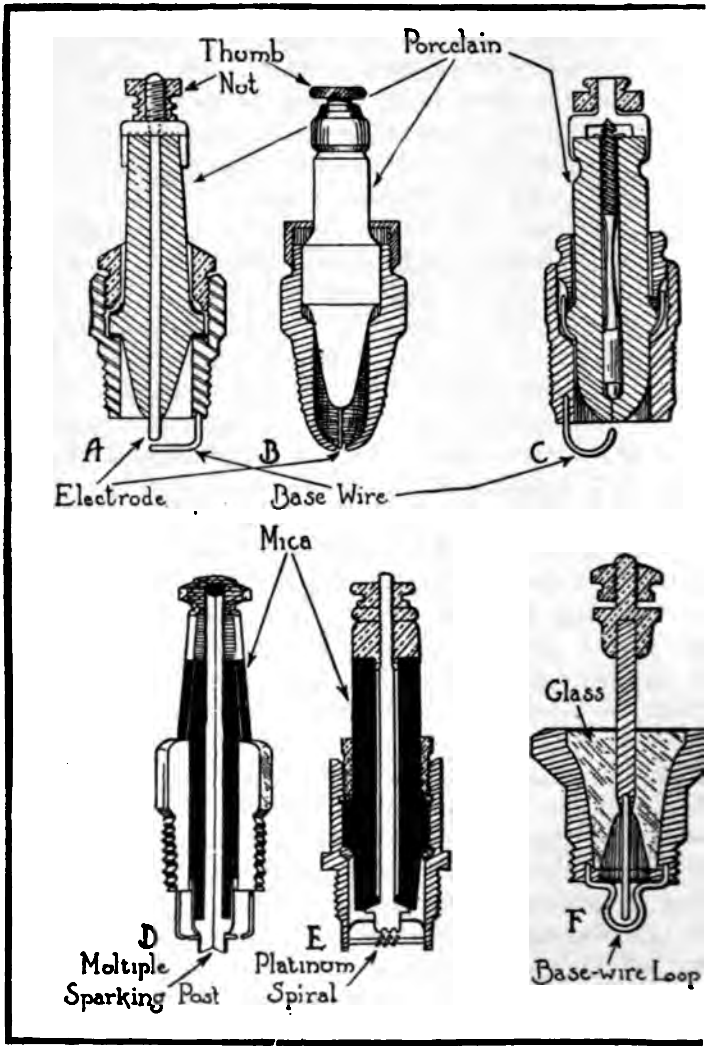


Fig. 240.—Showing Construction of Typical Spark Plugs.

in order to form a seating for the thumb nuts. The form outline at A is the type of plug most generally used, as it is a simple an effective design. It is easier to clean the points or the interio of the body than in the form shown at B, which has a close end and which must be dismembered in order to remove the soot deposit from the insulator surface. The type of plug at C ha a very fine wire imbedded in the lower portion of the porcelair which is in connection with a conductor of heavier material use to transmit the current from the terminal nuts to the fine wire The theory of action of a plug of this nature is that the fine wir is not so apt to be short circuited by soot as the projecting elec trode forms are, and that the spark tends to clear away materia that might short circuit the current by burning it.

The plugs shown at D and E have mica insulators instead o porcelain. When mica is used a sheet of that material is wrappe around the central electrode several times, after which a serie of mica washers is clamped tightly together and turned down t form a smooth insulator. The plug at F is the only one mar keted using glass insulation. Other plug forms made on the sam general principles as that at A use lava or steatite as an insu lator instead of the porcelain or mica. For all-around service th porcelain insulator gives the best results, as the mica and lav insulators are apt to become oil soaked and permit the curren to short circuit through the insulator and the plug body instea of jumping the air gap. Another representative form of spar plug showing the proper space between the spark points is show at Fig. 241, A.

The plug at B is one that combines a priming feature and i intended for use in engines of the Ford type in which no pro vision is made for using priming cups or compression relief cock The plug body is formed in such a way that a needle valve fittin may be screwed into it, this being intended to close a passagewa communicating from a channel around the top of the plug bod to the interior of the plug body. It is said that if this needl valve is opened for a minute or so while the engine is runnin that there will be a tendency to clear the plug points of any loos oil or carbon. *The compression* may be relieved by opening t

needle valve, and if it is desired to inject gasoline into the cy to promote easy starting this may be easily done by fillin channel or groove on top of the plug body with the fuel, opening the needle valve to allow it to pass to the plug int The gasoline will run down the walls and collect aroun spark points, where it will be readily ignited by the spark.

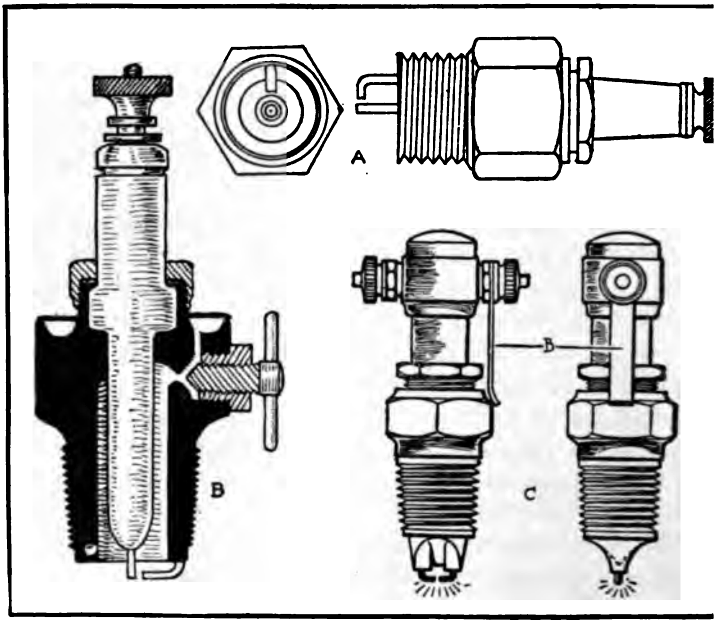


Fig. 241.—Spark Plug with Priming Arrangement and Two Pole S Plugs.

It is sometimes desirable to have two sparks occur in th inder at the same time, especially on engines of the T-head used for racing. One spark plug of the special form shown is used in connection with a regular spark plug of the form s at A, the special plug being placed first in the circuit and ; to the regular plug by a length of wire bridging the free ter of the plug at C with that on top of the insulator of the r *pattern.* As the plugs are in series, the current must jum

ıf both plugs and thus two sparks occur, which is said to ıse power by accelerating the rate of flame propagation, which urse results in more energetic ignition. The insulator is d to form a double V, the sides being slightly concave and : than the center V, which ends in a sharp point. This con- ion is said to cause the point to be self-cleaning by the ex- n. Two electrodes pass through the insulating member in- of one, these being insulated from each other and the plug as well. The high tension current enters one terminal and ı down one of the electrodes, jumps the air gap, and can reach the ground if the terminal connected to the second ode is in electrical connection with the terminal of an ordi- form of spark plug or if it is bridged down to the plug body e keeper B. When this keeper is in place, as indicated, the will act the same as a single electrode sparker. When the is to be used for double ignition in connection with one of gular forms, the keeper B should be removed and a short used to join the terminal to which the keeper was attached ı terminal of the regular pattern spark plug.

ark plug troubles are not hard to locate, as they may be y determined on inspection. If an engine misses fire, i.e., irregularly, it is necessary to locate the spark plug at fault ler to remove it for inspection or cleaning. The common d of doing this is to short circuit the spark plug terminal ome metallic portion of the engine by using a wood handle driver, as shown at Fig. 242, A. Each plug is tried in turn, hen a good one is short circuited the engine will run even : than before. If a plug is short circuited and the engine ot run any slower or work differently, one may assume that ug is defective or that the cylinder is not firing for some reason. A very simple spark plug tester which can be made y repairman for use on cars employing magneto ignition or ension battery-distributor ignition, is shown at Fig. 242, B. onsists of two strips of brass riveted together at one end and into a fiber or hard rubber handle. The brass strips are l apart so that contact may be made between the plug body ulated central terminal of *practically* any size plug. When

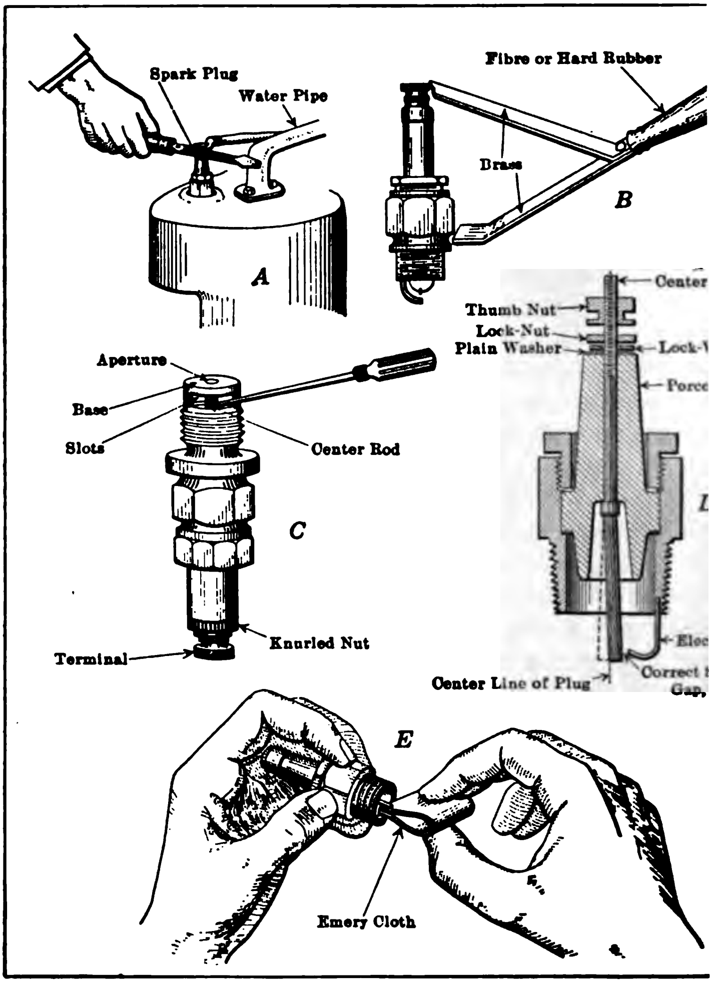


Fig. 242.—Showing Methods of Testing Spark Plug and Adjustin Gap Between the Electrodes.

a four-cylinder or six-cylinder engine uses individual spar for ignition, it is possible to detect the missing cylinder by h *down the coil* vibrators with the fingers, leaving the engine

on one of the coil units or one cylinder as the others are cut out. Each coil unit is tried in turn, and when all others are rendered noperative except the defective one or the coil leading to the lefective spark plug, the engine will stop. The wire leading from he spark coil is traced to the spark plug, and that member renoved for examination. The common trouble is a deposit of burnt il or carbon around the insulator and between the plug points. This short circuits the current as it provides an easier path for the passage of electricity than the air gap does. If the points are too close together the plug will become short circuited very quickly and ignition is apt to be erratic because the spark does not have sufficient heat to ignite the mixture. If the spark points are too far apart the resistance is apt to be too great for the current to jump the air gap. The porcelain may crack or become broken, in which case the current is apt to short circuit if the break is down in the plug body. If a mica or lava insulator becomes oil soaked, this also will produce short circuit.

Most plugs are of the easily separable form, as shown at Fig. 240, A, in which case the insulator may be easily removed by unscrewing the packing nuts that keep it seated against the plug body. If the plug is clean when examined the thing to do is to see that the spark gap is correct. This should be about one-thirty-second inch. Whenever a spark plug is to be put into use, whether it is a new one or old one which has been cleaned, the spark points should always be set so there is a gap of about the thickness of a smooth ten-cent piece between them. The method of obtaining a correct spark gap depends entirely upon the type of the plug. In the plug shown at Fig. 242, C, which has a plate at the end, it is necessary to bend over the center stem by using a small screw driver or similar tool as indicated. With a plug of the form shown at D the center stem is bent the proper distance away from the small hook-shaped wire or electrode which projects from the bottom of the spark plug body. In some plugs it is easier to bend the central stem than the side electrode, as the latter is of hard material, whereas in others it is not possible to bend the central electrode and the point attached to the plug body must be bent instead. It is important when replacing the por-

celain insulator after cleaning to make sure that the packing nut is drawn down quite tight in order that the joint will be tight enough to hold the explosion pressure. It is also necessary to screw down the small hexagon lock nut on top of the spark plug porcelain, as if this is left loose the center stem of the plug will be free to turn in the porcelain, especially if the thumb nut or terminal is being tightened. It will be apparent that if the center stem is bent over toward the side electrode in the manner shown at D, that if it is turned a very small part of a circle the size of the gap between the center stem and side electrode will be altered appreciably. If the porcelain is found covered with oil and carbon when removed, it should be thoroughly cleaned, care being taken not to scratch the glazing on the porcelain surface, as if this glaze is destroyed it will be possible for the porcelain to absorb oil. The interior of the plug body and the electrodes shoulc also be scraped clean of all carbonaceous matter. If the porcelair is scratched or defaced in any manner it should be replaced witl a new one. If the plug is apparently in good condition and ye the cylinder refuses to fire, it may be well to substitute the plu with one known to be in good condition, as there may be som minute short circuit in the porcelain that is not apparent upo inspection.

Plugs using mica insulation are very deceptive, as in many case short circuits exist that cannot be detected by the eye in daylight A good way to test a suspected mica plug is to lay it on top of th cylinder after dark, taking care not to have the insulated termin in contact with any metal parts except the high tension curren lead. The engine is then run on the other cylinders and th inside of the spark plug watched to see if sparks jump betwee the insulator and the plug body, instead of between the point If a short circuit exists it will be easily detected by the minut sparks plainly evident in the darkness. It is sometimes possibl to test a plug out in daytime by shading it from the light in som manner, as with a black felt hat. After the spark points hav been set correctly, it is well to double up a piece of emery clot with the abrasive surface on the outside, as shown at Fig. 242, I and move it back and forth between the plug points a number

times to brighten them up and to insure that there will be foreign matter present between them that is apt to short circ the current. An old tooth-brush and gasoline are the best to for cleaning a spark plug without taking it entirely apart as s brush bristles will remove any oil or material soluble in gasoli Acetone is a solvent for carbon, and if that material is not bak on too hard it is possible to remove the deposit without scrapi it off.

Many cases of ignition trouble have been traced to the ı of improper spark plugs or to faulty location of these membe Manufacturers of spark plugs have given the matter of locati considerable thought during recent years, and the endeavor is produce a plug specially designed or adapted for the motor : which it is to be used. The spark plug shell or base is construct so the spark points will project into the combustion chamb It is also important to make provision for proper cooling of t spark plug. This last named factor is an important one that seldom given consideration by owners or repairmen who char the spark plugs without making sure that they are adapted to t motor. To obtain the greatest efficiency from the explosion it important that the spark points project into the combustion cha ber in such a way that they be surrounded with cool fresh gas. the gap of the plug is located in a recess or pocket, as indicat at Fig. 243, A, dead gas is apt to accumulate about the poir and combustion will be much slower than it would be with t spark plug located as at D. It will be evident that with t construction of the valve cap the spark points project into t induction chamber, permitting the spark to take place in fr mixture and promote rapid spread of the ignition flame. Anotl faulty mounting when a plug is located directly in the combusti chamber is shown at C. It will be apparent that with a projecti from the plug body having a space around it in which the l gases may collect, the plug will heat up much quicker than t mounting shown at D in which the heat will be conducted aw by the cooling water. A plug that becomes heated will tend soot up and carbonize much quicker than one in which provisi have been made *for proper cooling.*

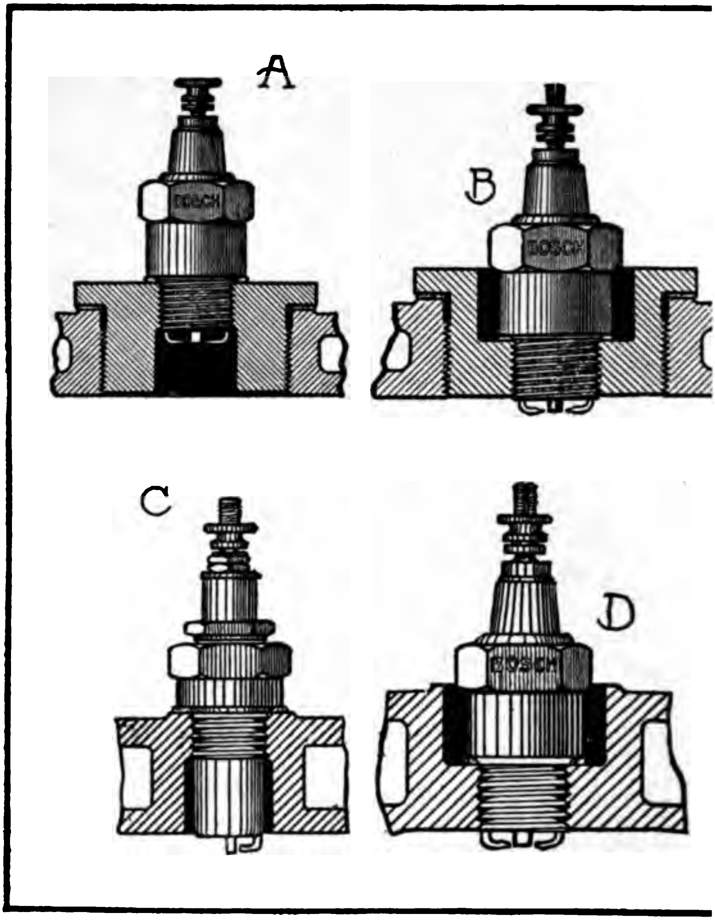


Fig. 243.—Illustrating Proper and Improper Methods of Spark Installation.

Induction Coil Faults.—The high tension induction coil part of the ignition system that can seldom be repaired of the factory. In the first place it is not possible to rea interior parts of an induction coil because the **windings** ar denser are usually imbedded in a hard **insulating compou** *has been* poured into the coil box in a **molten conditic**

hich becomes as hard as stone when it sets. The only part of ı induction coil that is possible to correct is faulty vibrator :tion, and fortunately the vibrator is about the only part of a ell-made coil that demands attention. If the vibrator does not ızz when the circuit is closed at the timer and the wire leading om the timer to the coil unit is found in good condition, the ouble is due to a broken connection inside of the coil box or the ntact points do not touch. If the vibrator operates as it should ıd there is an extremely bright spark between the points and weakened secondary spark, it is reasonable to assume that the ndenser inside of the coil box is ruptured.

If there is a proper vibration or buzz at the vibrator and no condary spark from the high tension terminal, the trouble is either broken high tension connection or a short circuited secondary nding. Sometimes a wire inside of a coil is twisted off where fastens to the terminal screw, due to that member being turned ound several revolutions with a pair of pliers. A case of this nd may be fixed by removing the bottom or top of the coil box, the case may be, and making sure that the connection is re-ldered to the terminal post. A punctured winding or short cir-ited condenser can only be repaired by the coil manufacturer, :d in most cases it is cheaper to procure a new coil unit, which easily removed in modern coils, than to attempt to have the old e repaired.

When a coil unit is suspected of being defective it is easy to certain if this is the case by changing it for one of the coil ıits which is known to be in good condition. If the cylinder ıich was formerly served by the good coil unit now begins to ip, one may assume that the coil unit is at fault. If the trouble s not been due to other causes, the cylinder that was formerly fault will begin to operate as it should as soon as the spark ug is connected to the good coil unit which has been substituted r the one thought to be defective.

Adjusting Coil Vibrators.—The repairman who understands e vibrating spark coil is the exception rather than the rule. any are able to adjust a vibrator, but do not know how to locate oubles, or to remove the exposed component such as the bridge,

vibrating spring, etc., and reassemble the parts correctly. vibrator buzzes weakly when contact is made at the timer, tl thing to do is to test the battery to make sure that there i cient current available to operate the vibrator, then the (points should be examined to see that they are clean and s Various defective conditions are shown at Fig. 244, A; ai of these will interfere with correct contact and with proj

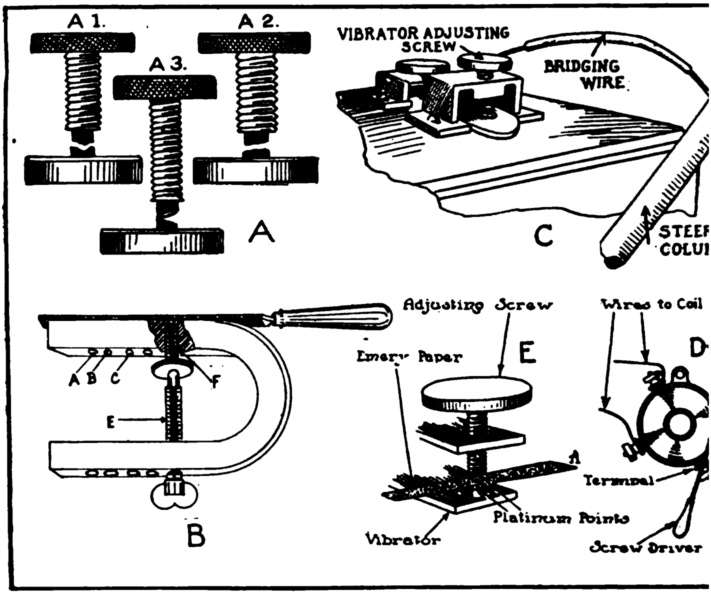


Fig. 244.—Care and Adjustment of Vibrator Contact Points Out

brator action. At A-1 a pit has been burnt in the lowe and a projection has been built up on the upper one. the points have been cleaned with a file which has been i at an angle so the contact members do not have a true flat s At A-3 a point has been built up on one side of the contact (vibrator springs and contact screw points. As these contact are of platinum it is important to remove as little of that v *material* (which is now worth more than gold) as possible.

For this reason it will be desirable for a repairman worki on cars using vibrator coils to provide himself with the sim] fixture shown at Fig. 244, B, which insures that the points w be dressed true without removing much material. The fixture a simple U-shaped piece of hardened steel having a series of hol A, B, C, drilled into it of such size as will permit the inserti of the most commonly used sizes of vibrator adjusting scre These are not threaded, the screw F being a free fit in the h corresponding to the outside diameter of the thread. A feed scr E may be interposed under the adjusting screw in order to feed up against the smooth file used to clean off the roughness. T screw may be shifted into any one of the tapped poles under t holes A, B and C for feeding different sized contact screws.

The conventional vibrator is shown at Fig. 244, C, and anoth form at Fig. 245. It will be noticed that this consists of a vibra spring or armature carrying one contact point and a bridge me ber over it carrying another contact which is set into a knurl head adjusting screw in that at Fig, 244, C. The smaller brid holds the vibrator spring and is also provided with a knurl screw so the vibrator spring tension may be adjusted. Direc under the vibrator is the iron core which attracts it to break t contact between the points. The farther away the vibrator is fr the core the more current will be needed to actuate the vibrat The spring tension should be sufficient, so that the trembler w vibrate fast enough to produce a pronounced buzzing sound. the vibrator spring lacks elasticity, too much current will be co sumed which is an important item if the current for ignition derived from a dry cell battery. In adjusting the coil vibrator is not necessary to turn the motor over to establish contact as t tuning up may be readily performed on most coils by connecti a wire to the steering post as shown at C, and touching the knurl head of the adjusting screw or the bridge carrying it with t other end of the wire. It is necessary, of course, to have the swit on the coil in the "on" position. Another method of accompli ing this is to short circuit the timer with a screw driver as sho at B, which is used to bridge the wire terminal and the alumin timer case. In this way each of the vibrators may be made to b

in turn. If the points are not too badly burnt it is poss clean them with a piece of very fine emery cloth as shown 244, B, without removing either vibrator or contact screw fr top of the coil. Where battery current is used it is well the current consumption of the coil from time to time as brators are adjusted. It is possible to have a coil draw t much as needed if the vibrator spring tension is too great

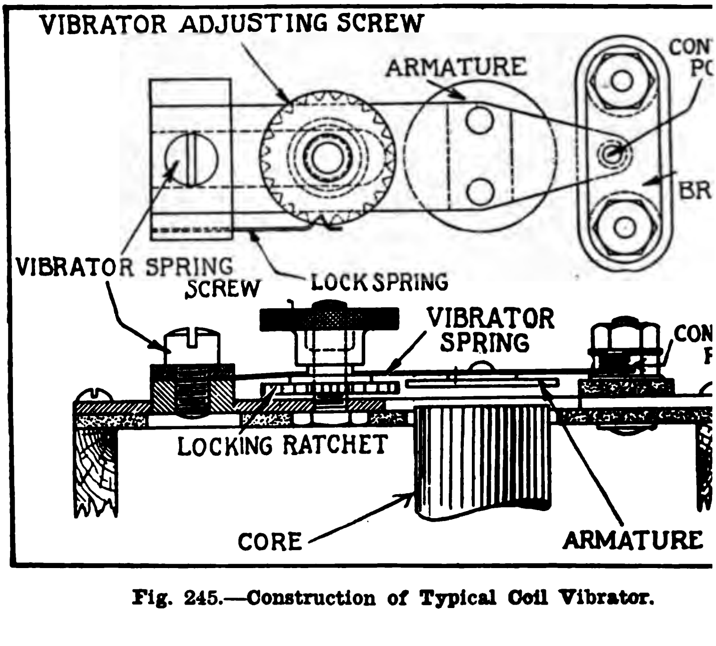
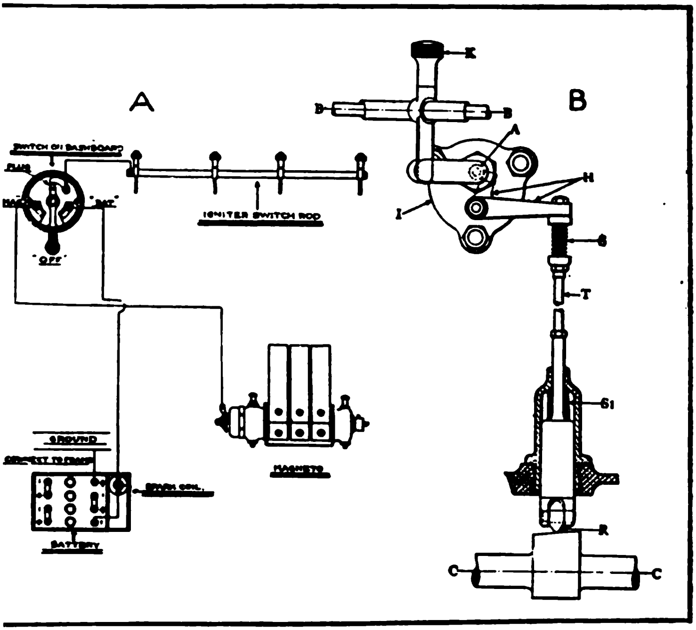


Fig. 245.—Construction of Typical Coil Vibrator.

current consumption will vary from .5 to 2.2 amperes, a fai age being about 1 ampere. The usual primary voltage ne 5 or 6, and the trembler vibrations will vary from 100 to 4 second. If the vibrator tends to stick, the core should l off as well as the undersurface of the vibrator to remove a that may be present between the surfaces. A projecting co sometimes interferes with proper vibrator action. Make s *top of the* core is smooth and bright.

Tension Ignition Systems.—The low tension ignition sys- which a spark is produced in the cylinder between moving es is seldom used at the present time in automobile en- xcept those of old models. The complete wiring diagram ow tension system used on the Locomobile cars for a time n at Fig. 246, A, while the actuating mechanism and the



6.—The Locomobile Low Tension Ignition System and Igniter Used for Producing Spark in the Cylinder.

plate construction is shown at 246, B. It will be observed low tension is a very simple one electrically, but that con- e mechanism is necessary to operate the make and break in the cylinders. In the wiring diagram it will be ap- hat two sources of ignition current are available, one a low magneto for regulating ignition, the other a storage bat- event of the low tension magneto failing to deliver current. re runs from the magneto to one side of the switch on the

dash-board. Another wire runs from the spark coil, which is placed in series with a storage battery, to the other side of the switch. From the top of the switch a wire runs to the igniter switch rod or busbar which delivers the current to the four igniter plates, one in each combustion chamber. The igniter plate is an approximately triangular member I attached to the combustion chamber wall by three bolts. It carries an insulated contact member A which is fixed, and an oscillating contact member H which is worked by a lever outside of the cylinder which is actuated by a tappet rod T, lifted by the cam C. A spark takes place between the contact points when the hammer member H breaks contact with the anvil member A. The break takes place when the roller R drops off of the cam profile. This can be timed to occur when desired by suitable regulation means on the tappet rod T. The switch handle K which joins the busbar B to the switch member projecting from A, is necessary to interrupt the igniters in order to locate a cylinder that is misfiring.

About the only thing that can occur is fouling of the contact points by carbon deposits and excessive mechanical depreciation of the actuating mechanism. Either of these troubles is easily determined on inspection and the remedy is obvious.

Trouble is sometimes experienced with the low tension magneto, which is shown in section at Fig. 247. The form shown uses plain bearings and as these require considerable lubricant it is possible for the collecting brushes or armature winding to become oil soaked which interferes with proper delivery of current. It is also important to time the low tension magneto so that the contact points of the igniter plate I will separate when the armature of the magneto has attained its position of maximum current generation. This will be considered in detail in connection with the high tension magneto as will other magneto troubles, so it is not necessary to consider them at this time. It is important that the contact brush shown bearing against the side of the armature and the contact member A, be making a positive connection with the parts they are intended to bear against. Failure of the low tension magneto to deliver current is usually due to poor contact at these points which may be produced by particles of foreign matter or

which may result if the springs maintaining the parts in cont[...] have lost their elasticity. Generally the trouble is gummed which is easily removed with gasoline. Sometimes the current [...]livered by the armature short circuits because of a cracked or soaked insulator which carries the contact rod C.

Magnetic Spark Plug Systems.—Other low tension igniti[...] systems have been devised though they have never received wi[...]

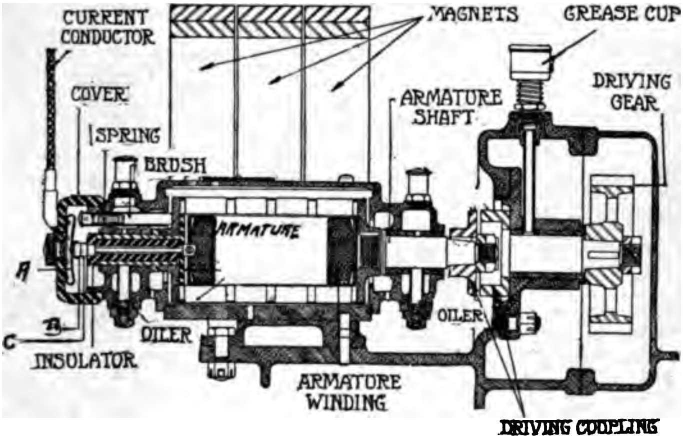


Fig. 247.—Magneto Used with Locomobile Low Tension Ignition Syste[...]

application in which the moving mechanism needed to operate t[...] igniter plates from the camshaft have been replaced with magne[...]cally operated spark plugs, the leading example of which is t[...] Bosch shown at Fig. 248, A. This consists of three main parts[...] supporting member which screws into the spark plug hole in t[...] combustion chamber, an electro-magnet and oscillating mechanis[...] The electro-magnet contains a coil of wire D, and is protected [...] a cover B, and iron outer shell A. A cylinder H which is thread[...] at its lower end projects into the coil. A collar R forms t[...] base of the magnet. The oscillating mechanism consists of a p[...] piece E, a horse-shoe shaped spring G, and an armature F. T[...]

lower part of the pole piece is provided with threads to hollow cylinder H, and is formed externally to be retained support K by a retaining nut or collar L. The supportin ber has the upper half of hexagonal form the same as any plug body and is threaded to fit the spark plug apertu steatite insulating member J in connection with the packi ket insures against loss of compression or explosive pressure

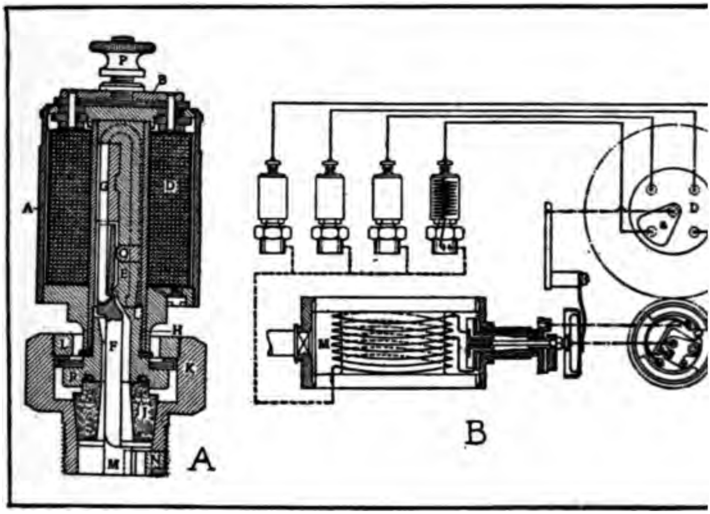


Fig. 248.—The Construction and Application of the Bosch Ma Plug.

The operation of the plug is very simple, as when the te P is connected to the source of current when the electricity through the coil it magnetizes the core E, which attracts the ture F, pivoted on a knife edge extending from E to the this separating the contact points M and N and produ spark. A brass plug O is inserted in the core E so the ar will not stick to the pole piece due to magnetism. A sp tends to keep the points M and N in contact. The poin attached to the spark plug body and is V shaped, the othe on the armature being formed to fit into the V portion of

complete ignition system is shown in diagram form at Fig. and is very much the same as the wiring for a high tension › using jump spark plugs. In addition to the timer or breaker which is of the usual form, the magneto must in- distributing device which will allow the circuit to flow lug in the cylinder about to fire a charge. The distributor of four contact points carried by a body member of in- material and a rotary distributor arm that makes contact ꞓ different contact points in turn according to the firing : the engine. The principal trouble apt to occur with the c plug is short circuiting due to carbon deposits or ac- ions of oil which will interfere with prompt action of the ng armature F. If the spring G breaks, the operation of ; will be erratic and the engine will misfire. This system ɜived but limited application on automobile engines, but ı used to some extent in marine engine work so the repair- ɔuld, at least, be familiar with its principle of operation r to have a reasonably complete knowledge of electrical methods.

ng Troubles and Electrostatic Effects.—The principal that are apt to occur in the wiring systems are evident ɜction, these consisting usually of a break in the conductor, ıay sometimes be concealed by perfect insulation covering; away of the insulation due to abrasion between the wire ıe metal portion of the car which eventually results in a rcuit and the wiring becoming oil soaked and failing to ᵧ carry the charge of current which leaks through the de- insulation. The wiring of a complete dual ignition sys- which two radically different methods of ignition are used ı at Fig. 249. One system consists of a set of low tension plates mechanically operated from a suitable camshaft, the ethod, which is independent, has high tension ignition plugs l through a timer of the usual form. At the present time lual ignition systems are provided the usual practice is wo high tension systems, one of which will derive its cur- ɔm a battery and coil, the other which will receive the of a high tension magneto. A typical double system

adapted for six cylinder engine ignition is shown at Fig. 250. In this two spark plugs are carried in each cylinder, one over the intake, the other over the exhaust valve. A battery timer is mounted close to the dash from which six primary wires go to the individual coil units of the coil box. High tension wires come

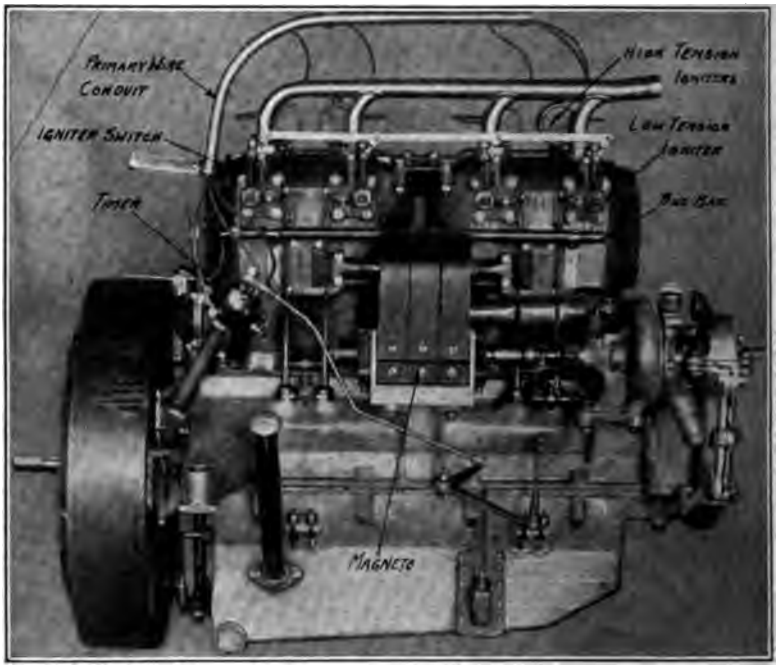


Fig. 249.—Side View of Engine Used on Early Columbia Automobile Having Both High and Low Tension Ignition System.

from the bottom of the coil to one set of spark plugs. Another set of high tension wires extends from the magneto distributor to the remaining set of spark plugs.

It will be apparent that in both of the systems shown that considerable care is taken to have the wiring carried in an orderly manner and kept out of contact with the metal portions of the cylinder by suitable insulating blocks, usually made of fibre, as at *Fig. 250,* or in a fiber-lined metallic conduit, as shown at Fig. 249

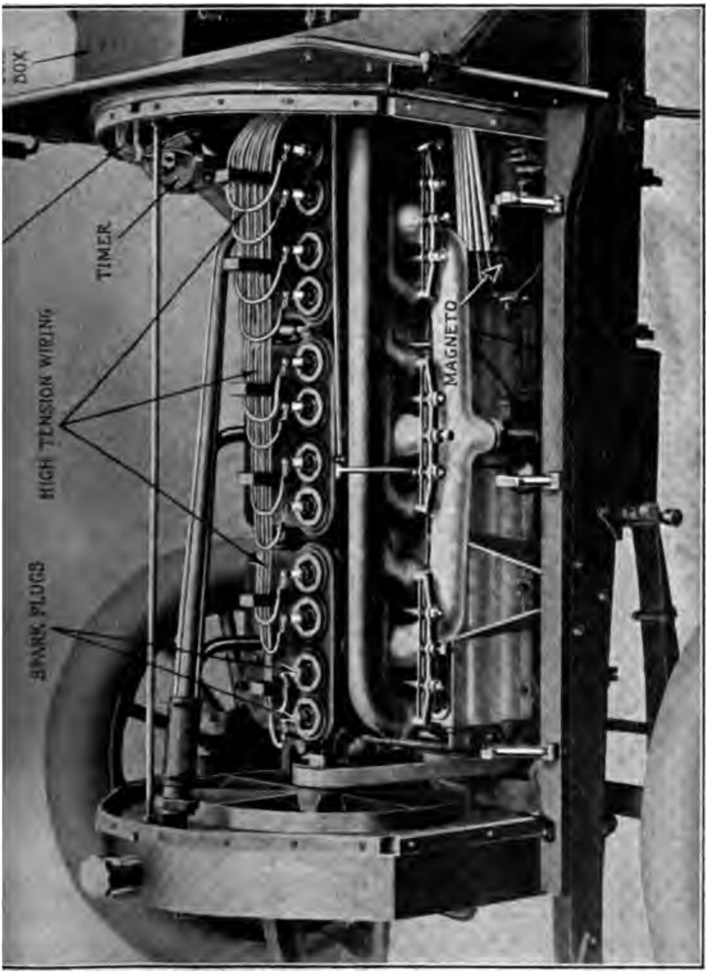


Fig. 250.—Top View of Stevens Duryea Power Plant, Showing Wiring and Other Components of Double Ignition System.

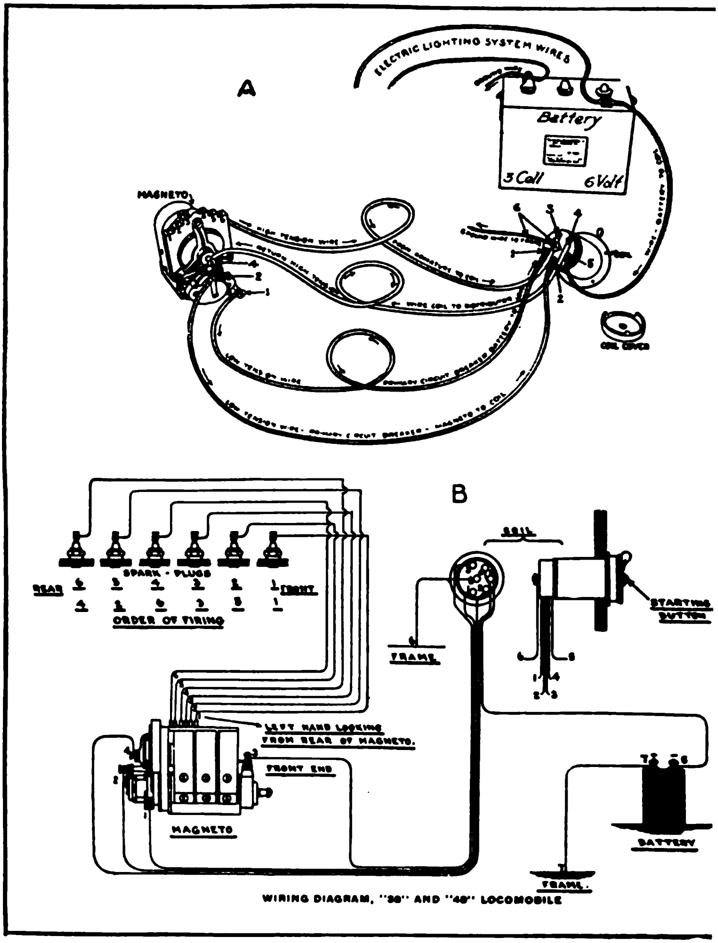


Fig. 251.—Wiring Diagram of Locomobile High Tension Igniti

A typical double ignition system which has been **used o** models of the Locomobile is clearly shown **at Fig. 251. The** of running the wires for the primary circuit **is very clear** lined at A. The complete wiring diagram **showing the hi** sion leads going from the magneto distributor **to the spark** *shown at B.* With a system of this kind the **current may**

rived from a battery which is timed by a primary circuit breaker attached to the magneto contact breaker box and sent through a single unit coil secured to the dash. The secondary current from the coil is led to the center of the magneto distributor, which serves the dual purpose of directing the high tension current from either the magneto armature or the induction coil to the spark plugs in the proper firing order. The usual method of housing the secondary cables in a conduit of insulating material so that there will be no liability of short circuiting due to oil accumulations or to contact with metal parts is so clearly shown at Fig. 251 that further description is unnecessary.

The repairman does not generally recognize the fact that the manner in which the high tension cables are led from a magneto or spark coil to the spark plugs is sometimes the cause of misfiring and ignition irregularities which are hard to locate. A spark may sometimes occur in a cylinder in which the piston is going down on its suction stroke which is not due to defective insulation of the wires or to short circuiting, but to an electrostatic action between one wire and a neighboring one through which no current is flowing. Endeavor should always be made to keep the secondary cables as short as possible, as in some cases if a conductor is too long the tendency is toward an unreliable spark. Some ignition experts condemn the practice of running the secondary wires close together in a fiber-lined conduit and recommend the use of fiber cleats secured to supports extending from the engine and provided with grooves that will hold the cables some distance apart.

When individual unit coils are used a condition that often puzzles those who have had no previous experience with it is what is known among old-time repairmen as "bucking," this usually being evidenced on engines of the four or six cylinder forms. The symptom is the same as a premature explosion in some one of the cylinders, this having a tendency to cause the engine to come to an abrupt stop. One is often led to believe that a short circuit exists at one of the timer wires which allows a contact being made at the wrong time, producing a spark in the cylinder about to fire before the gas is fully compressed or the piston has reached top center. This is *due to an induc*tive interference between one induc

tion coil and a neighboring one. It is known that when · mary coil becomes energized in any unit the core becomes a : and as is common with all bar magnets, lines of force are gi which run from the north to the south poles and which i current in the secondary winding of the transformer coil. magnetic influence does not stray from its proper confines ı ble will be experienced. If a portion of this magnetic fielc

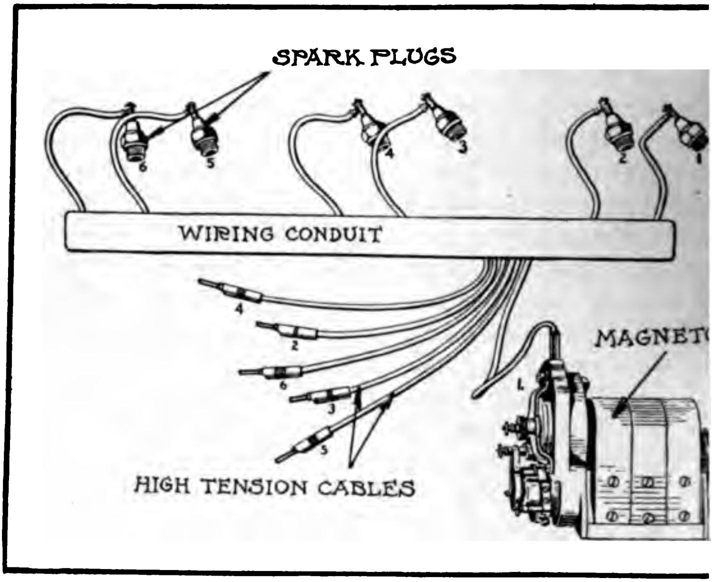
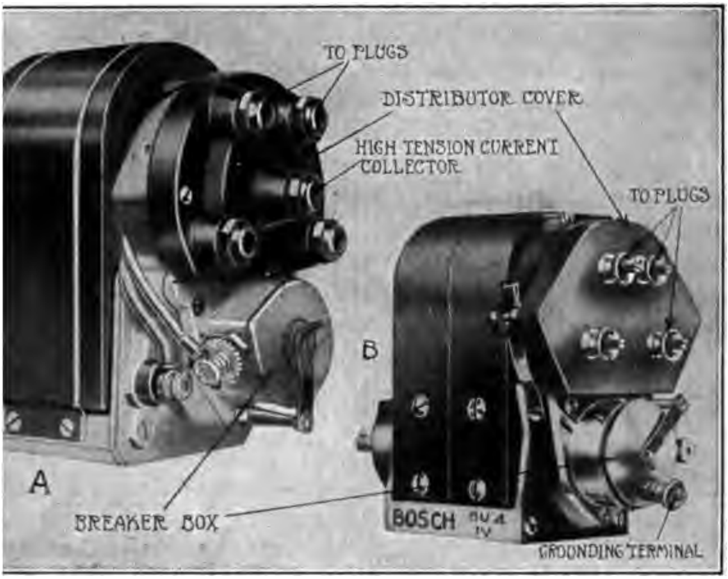


Fig. 252.—Method of Carrying High Tension Cables in Condı

over into a neighboring coil unit enough voltage may be i in the secondary winding of the latter to produce a weak s a spark plug connected with a coil which rightly should inactible. This condition is more noted with old-style in coils than with modern ones, and usually results when th is running slowly. The trouble has been eliminated in n the later forms of multiple unit coils by providing anti-in *shields* between the units. These are merely metallic st *which the* energies from the stray magnetic force is dissip

orm of eddy currents instead of cutting wire layers of adja- units. If this trouble is experienced and none of the com- faults are found to exist, such as carbon deposits and rough ; in the interior of the combustion chamber or long, thin spark points which remain incandescent and retain heat from a ous explosion, one may suspect trouble in the multiple unit



253.—External Views of Typical Magneto Ignition Devices. A.—The emy Magneto. B.—The Bosch Du 4, a True High Tension Type.

It has been cured at times by inserting thin strips of sheet between the coil units. The most frequent cause of "buck- ' is defective insulation of the secondary wires, which allows urrent to jump from one cable to another. This is sometimes d to be the case when all cables are passed closely together igh a common tubular conduit, and is not apt to result when s are carried apart in cleats.

roubles with High Tension Magneto.—Before describing the ous high tension magneto troubles it may be well to review ly the construction of typical magneto forms in order that the

repairman may become familiar with the principal types. High tension magnetos may be either one of two general forms, as shown at Fig. 253, it being practically impossible to distinguish between them from external appearances unless carefully examined. The magneto shown at A is a transformer coil type, i.e., it generates a current of low voltage, which must be intensified by a separate coil of the non-vibrator form, the high tension coil current being brought to a central terminal on the distributor and from that point led to the various spark plugs by the rotary distributing brush. The true high tension magneto, which is shown at B, is a complete ignition system in itself, and does not depend on any appliances other than the spark plugs in the cylinders and a small grounding switch. A high tension current is delivered from the armature directly to the distributing member and no separate transformer coil is needed unless the magneto is used with a dual system. The parts that demand the most frequent inspection in a magneto are the more accessible ones, these being the breaker box, which houses the contact points, and the distributor, which is utilized to commutate the secondary current.

The construction of a Splitdorf magneto is clearly shown at Fig. 254. The longitudinal sectional view shows clearly the component parts of the device. The armature is wound to produce only low tension current, so the magneto must be used in connection with a separate transformer coil. A sectional view of a true high tension magneto, the Eisemann, is shown at Fig. 255. This differs from that at Fig. 254 in that it employs a double-wound armature, which delivers a current of high potential to the distributor. The spark time is advanced and retarded on most magnetos by rocking the contact breaker back and forth by a suitable mechanical connection with the spark lever on the steering wheel. In the Eisemann magneto outlined an automatic spark control or advancing mechanism, which increases the lead of the spark as the engine speed increases, is included. The operation of this automatic timer is very much the same as that of the Delco automatic spark advance, previously described. The governor weights are carried by a sleeve or quill mounted on an extension of the armature shaft, which has a rectangular block sliding within

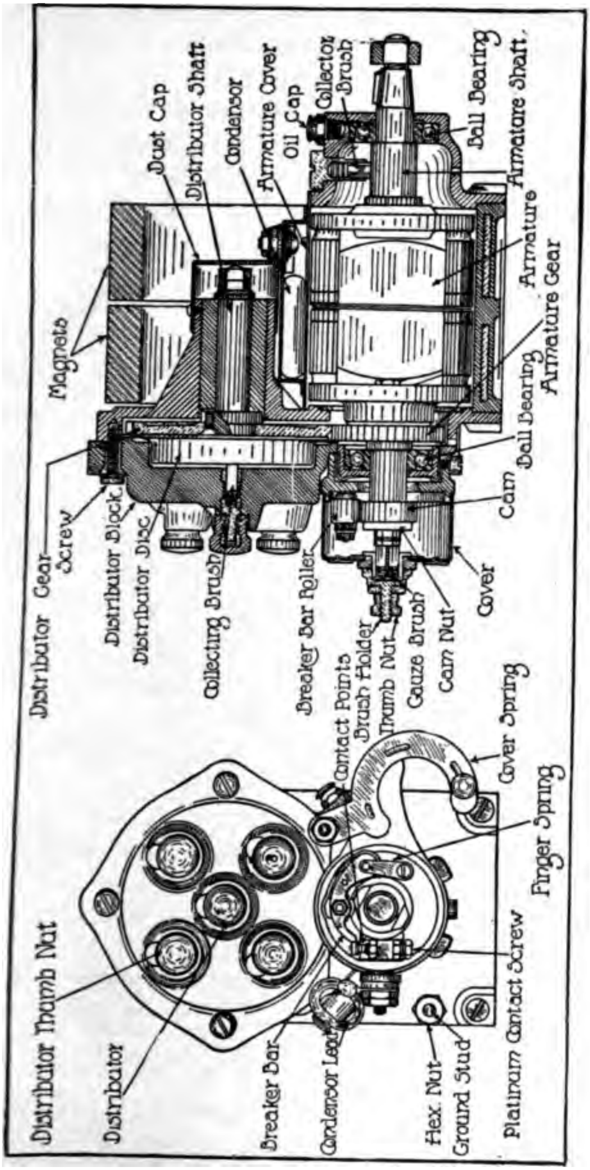


Fig. 254.—View Showing Construction of Splitdorf Magneto.

it. This block is threaded for receiving a spirally cut shaft, wh is driven by direct connection with the engine through some fo of gearing. The governor weights are attached to the sliding bl by means of links, and as the shaft is revolved the weights tend spread apart, and as they do the block is made to slide in t quill. In so moving it travels along the threaded shaft, which sults in slightly rocking the block. As the block oscillates it c

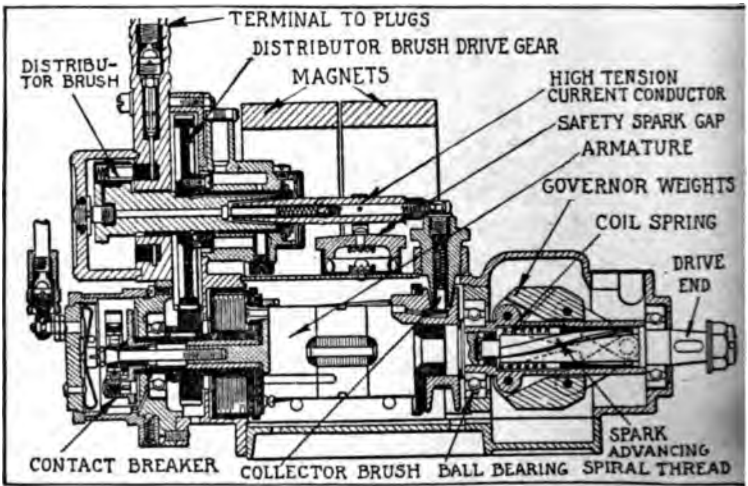


Fig. 255.—The Eisemann High Tension Magneto with Automatic Spar Advance.

ries the quill, in which it works, forward slightly and also t armature shaft to which the quill is fixed. The armature is th advanced and also the commutator, which is attached to the fro end of the armature shaft. As the speed increases the govern weights fly farther out and advance the time of ignition. Wh the speed diminishes the weights tend to close up, this being assis by the action of a coil spring, against which the governor weig work at all times. An automatic spark advance may be obtai from 18-57 degrees with this construction.

One of the most popular of high tension magnetos is show section at Fig. 256. This is of Bosch manufacture, and is kn as the D 4. The magnetic field is produced by the horseshoe

A, of compound form, which are attached to the pole pieces, pace between forming the armature tunnel, in which the e-wound armature B revolves. This carries a condenser, which with it, and also the rotating portions of the contact breaker. ırmature is supported on ball bearings in order that it rotate r. A small spur pinion, Q, is attached to the armature and

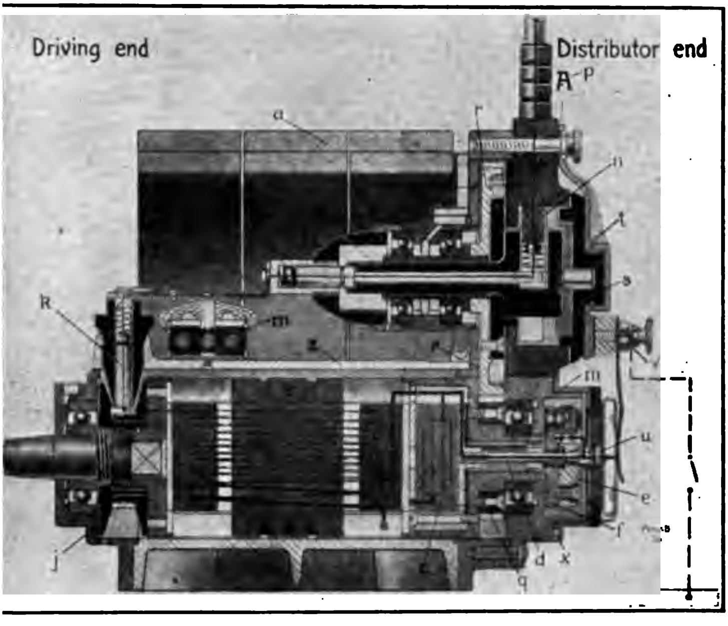
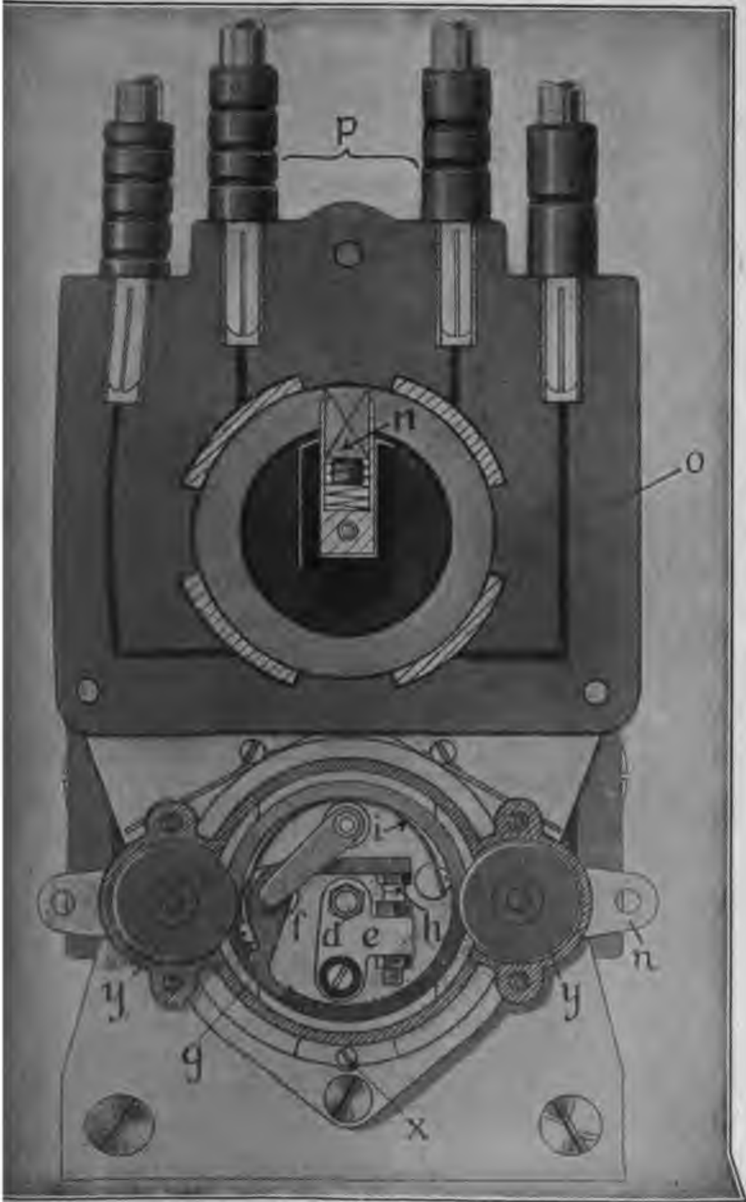


Fig. 256.—Sectional View of Bosch High Tension Magneto.

s to revolve a larger spur gear, R, which drives the distribu- The current generated in the armature winding is collected e brush K, which bears against the insulator collector ring J, ı is mounted on an ebonite spool to prevent current leakage. the brush K the current is conveyed by the connector L to er brush, which is in contact with the current conveying pen- , which delivers the electrical energy to the rotating distribu- rush N. The rotating parts of the distributor are mounted on earings in order to eliminate troubles due to bearing depre-

ciation. A safety spark gap M is attached to the dust cover Z, t function of this device being to act as a safety valve for the grou ing of any excess current, such as might be produced if the magn was run without having the distributor connected with the sp plug.

The arrangement of the distributor and the contact brea mechanism is very clearly outlined at Fig. 257. The distribut which is the upper portion, is employed in commutating the se ondary or high tension current only. The contact breaker or lo assembly breaks the primary circuit. One end of the coarse wi ing of the magneto armature is led to the fixed contact member by means of the screw plug D, which serves to retain the cont breaker assembly to the armature shaft. The contact breaker c ing, which is capable of oscillation but not of rotating, carries fiber cam rollers W. As the portion F of the contact breaker volves the toe portion of the bell crank lever G is pushed up in by the cam roller, this separating the contact point H from fixed contact point carried by member E. Every time that the c tact points separate a current of high potential is sent through connector member L and the conducting pencil N to the distri ing brush N. When the contact points separate this distribut brush should be bearing against one of the segments carried by distributor block O, this being in turn connected to sockets at top of the block in which the plug terminals P fit. The bell c lever G is kept pressed out by the flat spring I, which keeps the tact points together except at such times as they are separate the cam rollers Y. It will be seen by reference to Fig. 256 th the distributor brush N is driven by positive spur gearing th must turn in an opposite direction to the armature and at just the armature speed on account of the distributor gear R b twice the size of the pinion Q. The brush N is therefore rev in definite timed relation with a contact breaker assembly F the armature B. It will take two revolutions of the armatu produce one revolution of the brush N. This means that the tact points separate each revolution of the armature and th brush N makes contact with two of the distributor segment each turn of the armature.



257.—Front View of Bosch Magneto Showing Arrangement of Contact Breaker and Distributor Mechanism.

Another form of Bosch magneto which is practicall in general principles as that just described, except for ferences in the contact breaker and distributor, is sho 258. This is a smaller device, using two single horsesh and is intended for small engines up to 30 H.P. The l neto, with its three compound magnets, is more powerf

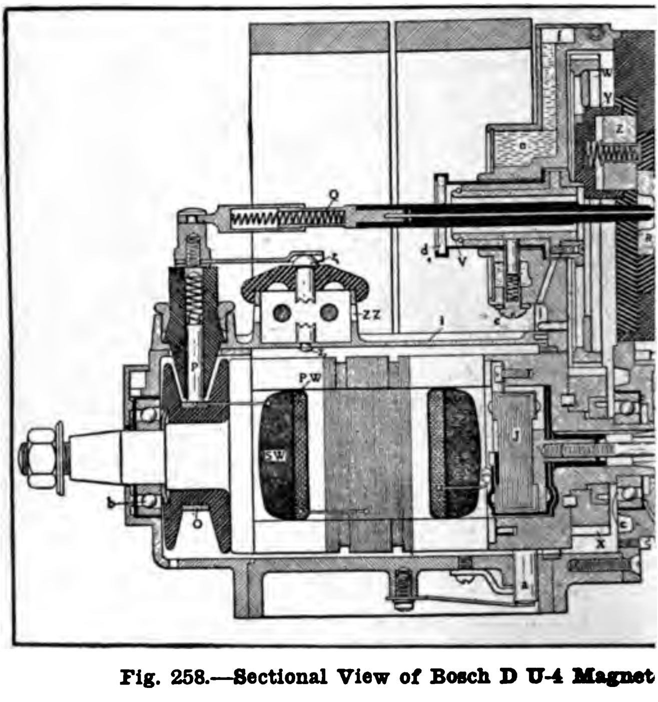
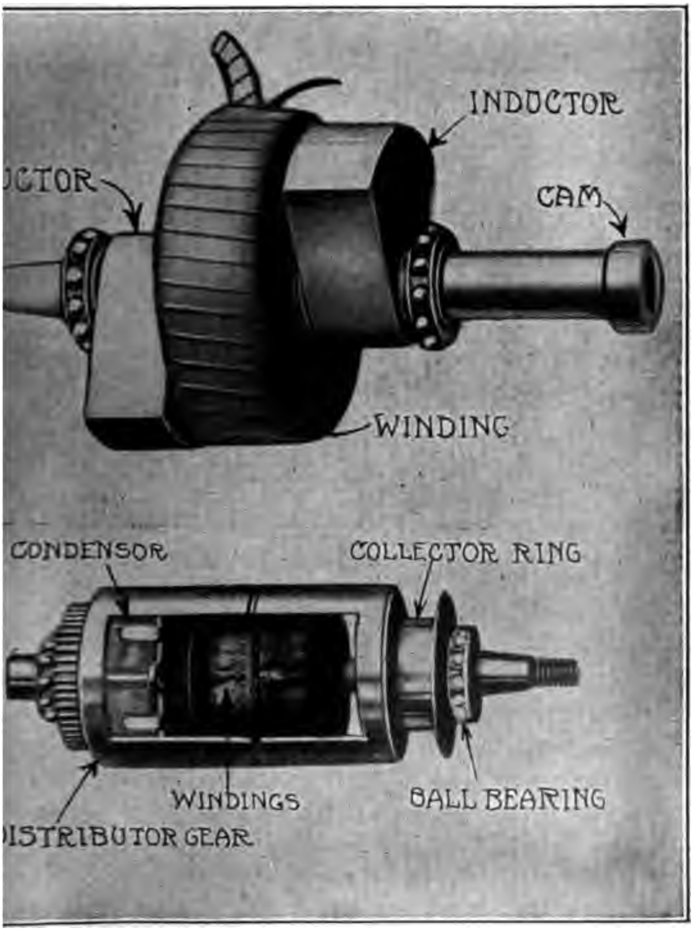


Fig. 258.—Sectional View of Bosch D U-4 Magnet

produce a hotter spark, such as is necessary to ignite th gas in large cylinders. The Bosch DU-4 magneto con and distributor are clearly illustrated at A, Fig. 261.

All magnetos do not have rotating windings, three K-W, Splitdorf Dixie and the Remy utilize a fixed win tary inductor, substantially as shown at top of Fig inductor pieces are used to conduct the lines of mag *through the* winding and produce the current by cutti

In the armature shown in the lower portion of Fig. 259
lings revolve in the magnetic field and generate the cur-
nother form of magneto which is used on but one make of
Ford, but which enjoys a wide distribution, is shown at
) in connection with the complete ignition system of the
kteen coils of coarse conductor are carried by a fixed plate,



—Remy Rotary Inductor Using Fixed Windings at Top, Con-
l Double Wound *Armature with Rotating* Windings at Bottom.

which is bolted to the engine crank case. A number of h magnets, not shown in the illustration, are carried by the the flywheel and revolve in front of the fixed coils, the sp tween the magnet poles and the cores of the windings bei enough to provide clearance without danger of hitting tl nets. Owing to the large number of magnets and coils en a very strong current is obtained, which, while alterna character, is used in the same way as battery current w

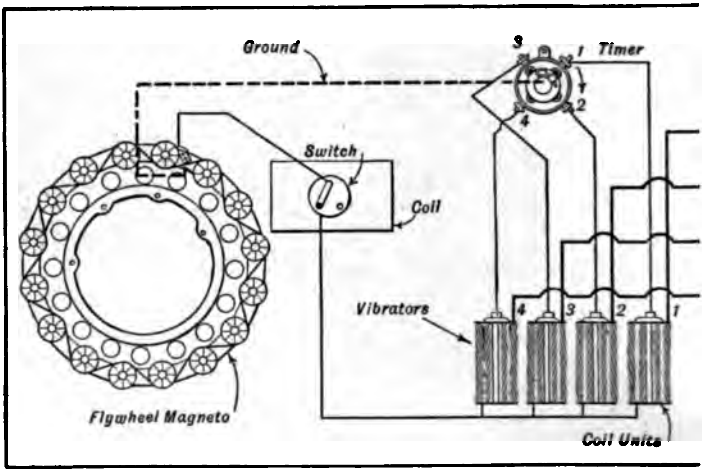


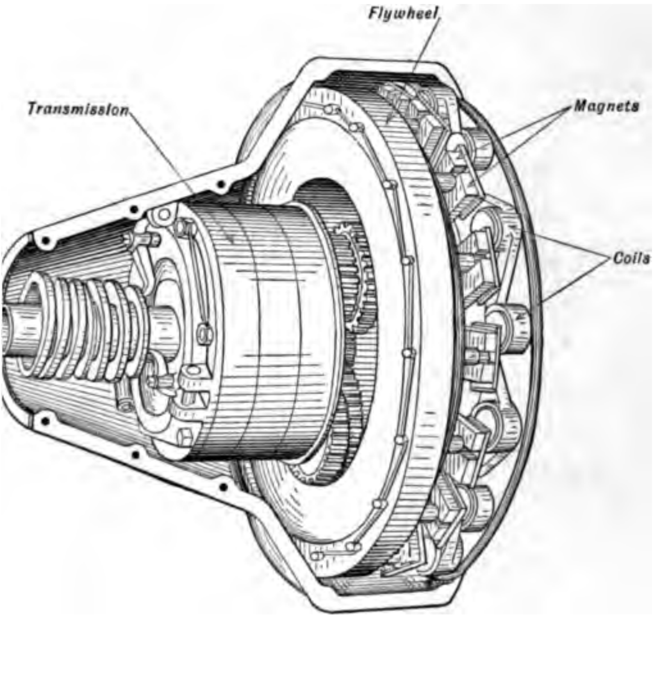
Fig. 260.—Diagram Showing Ford Magneto Ignition System

through four individual vibrator coils, which are broug circuit progressively by the rotary contact timer.

The most popular form of magneto, if one can judge numbers of manufacturers using it, is the true high tensi with the revolving winding, though the low tension typ transformer coils have also been used to a large extent.

In case of trouble with a magneto the point to be dete first of all, is whether the fault is with the current gene it is a true high tension form or in the plugs, or in the eve transformer coil being employed, if that member is at fa cases where only one cylinder is firing irregularly the fault

to be with the spark plug in that cylinder. The common s of spark plugs and the method of repairing them have reviously described. After the spark plugs have received on the cables must be tested to make sure that the insulation injured in any way or that the metal terminals at the end cable do not come in contact with any metal parts of the or magneto. If the ignition fails suddenly, one can suspect t circuit in the grounding cable, which is connected to the the magneto contact breaker and which serves for switching ition off. This may be easily ascertained by removing the rom the magneto and seeing if its removal enables the mag- run correctly. A spark leaping the gap in the safety de-



60a.—Showing Coils and Magnets that Comprise Ford Magneto and their Relation to the Flywheel and Transmission Gear.

vice indicates a broken wire or one that has become disconnect either from the plug terminal or from the distributor terminal.

If the cables and plugs are in good condition and the engi works irregularly, it is apparent that the trouble is in the magn if it is an ignition fault. In event of this, the most important thi to do is to make sure of the proper interruption of the primary cu rent. The spring holding the cover of the contact breaker in pla should be moved sideways and the brass cover taken off. It is th important to see if the screw D, Fig. 257, is tight. If this is foun

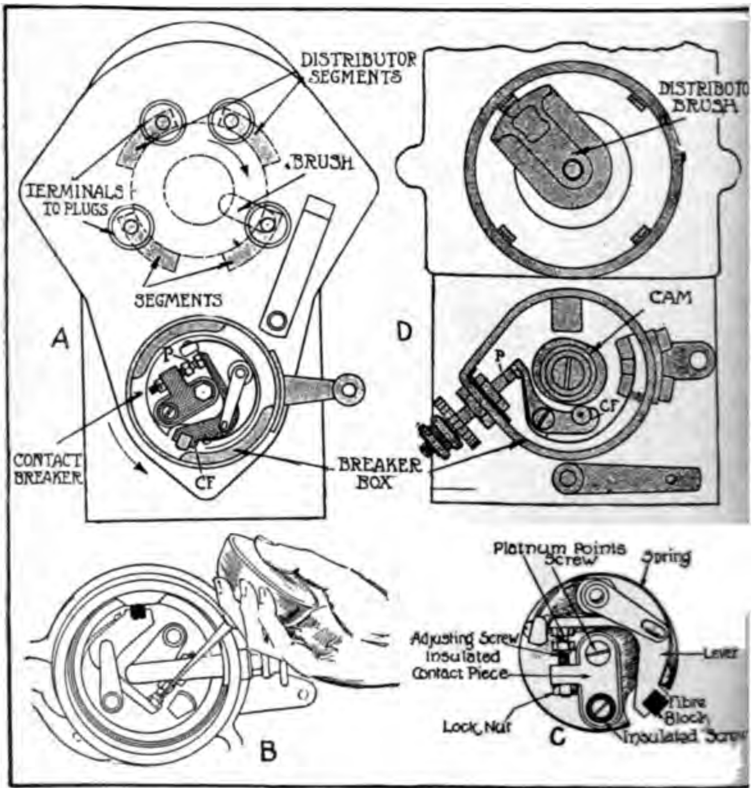


Fig. 261.—Illustrating Methods of Adjusting and Caring for Magn Contact Breakers.

to be set up properly the next thing is to make sure that the contact breaker points are in contact when the bell crank lever is out of contact with the cam in the sides of the breaker box in the type DU-4 or away from the fiber cam rollers in the type D-4. It is also important that the platinum points are separated by the proper distance, about .5 millimeter, when the lever C F at A, Fig. 261, is in contact with the cam. If the points are too far apart they should be brought nearer together by loosening the lock nut on the adjusting screw shown at C, Fig. 261, and screwing it up to lessen the difference, or to screw it back and open the gap if it is not sufficient. The platinum contact points must also be cleaned, any dirt or oil being easily removed, as shown at Fig. 261, B, by gasoline squirted on them from a small hand oil can. In case the contacts are uneven, pitted or blackened, they must be smoothed with a jeweler's fine cut file. After continued use, if the platinum points have worn down the platinum-pointed screw must be removed. It is also important to make sure that the high tension current collecting brush, K, Fig. 256, is in contact with the collector ring, and that the conducting pencil N makes proper contact with the brush, against which it bears. This high tension collecting brush is indicated as P, and the collector ring as O, in Fig. 258. The interior of the distributor must be clean and free of metallic or carbonaceous matter. The distributing brush must bear positively against the distributor section and the interior of the distributor should be smooth and all contacts clean and bright.

Mention has been previously made of making sure that the screw which keeps the contact breaker assembly in proper relation with the armature shaft is tight, which calls for careful examination. If this screw is loose, the contact breaker assembly will not move in proper timed relation with the armature; in fact, it may not move at all, which will prevent the contact point from separating and which will also result in failure of the ignition. If everything appears to be all right about the magneto, the timing should be verified to make sure that the spark is occurring at the right time in the engine cylinders. It is easy to tell if the magneto is producing a spark of proper intensity by uncoupling a spark plug conductor and holding it a short distance away, not more than

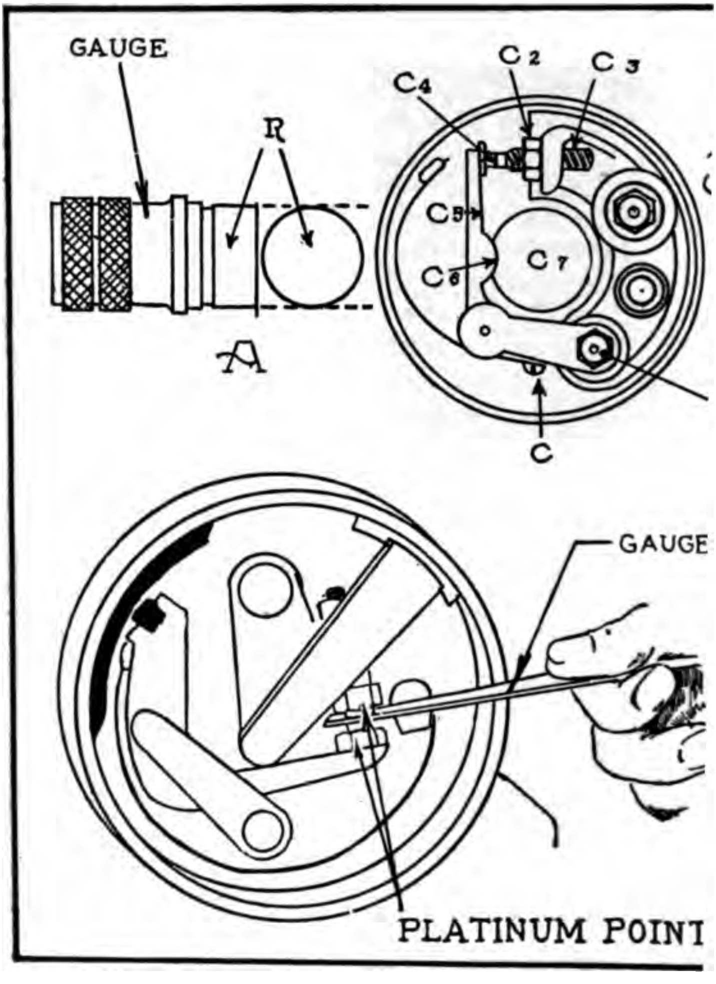


Fig. 262.—Outlining Use of Gauges in Obtaining Correct Set Magneto Contact Breaker Points.

⅛″ from the terminal. If a magneto is functioning pr
spark will jump the air gap thus created.

At Fig. 261, D, the contact breaker and distributor cons *of the* Remy magneto is shown. It will be **observed, in t**

that the contact breaker assembly does not rotate, as in the Bos but that a rotating two-point cam is attached to the armature sh and interrupts the contact between the points P by bearing agai the end of the bell crank CF. The instructions given for care the Bosch magneto apply just as well to this device. Realizing importance of having the gap between the contact breaker poi of the proper amount, the magneto manufacturers furnish gau which are to be used for testing this gap. That shown at F 262, A, is for use with the Eisemann magneto. With the cont breaker removed, as indicated at B, the contact points C-4 shou be together as indicated. When the gauge is inserted in the h C-7 it will indicate the correct amount the point should be se rated. The gauge at Fig. 262, C, is merely a piece of thin sh steel of the proper thickness which is used as indicated when points are separated by the bell crank lever riding on the cam blo

Recharging Weak Magnets.—After a high tension magn has been in use for a time the magnets lose their strength and is necessary to recharge them in order to restore the magneto its full efficiency. When magnets are weak the resulting second spark will also be weak and the motor will not run regularly, matter how carefully the device is adjusted. If the motor does r without misfiring it will not develop its full power if the magn are weak. An electro-magnet designed to operate on 110-volt c rent is shown at Fig. 263, A. The core is of soft iron, 1″ in ameter and 8½″ long. They are drilled at the bottom for a reta ing screw, which is intended to keep them in contact with a b plate of steel 4½″ x 9″. Two blocks of steel 1¾″ x 2″ x 4″ drilled to receive the cores, and have set screws in the side so tl can be clamped tightly against the core to form polepieces. brass tube about $\frac{1}{16}$″ thick at the side, having flanges at each e projecting over to hold fiber insulating plates as shown, may turned to the dimensions indicated in a lathe or may be made of sheet stock if desired. The hole through the center of the br spool is of such size as to permit the core to fit freely in its interi Besides this equipment, 22 lbs. of No. 20 B. & S. gauge insula copper wire will be needed. Eleven pounds is wound around ea brass tube, winding one coil in one direction and the other

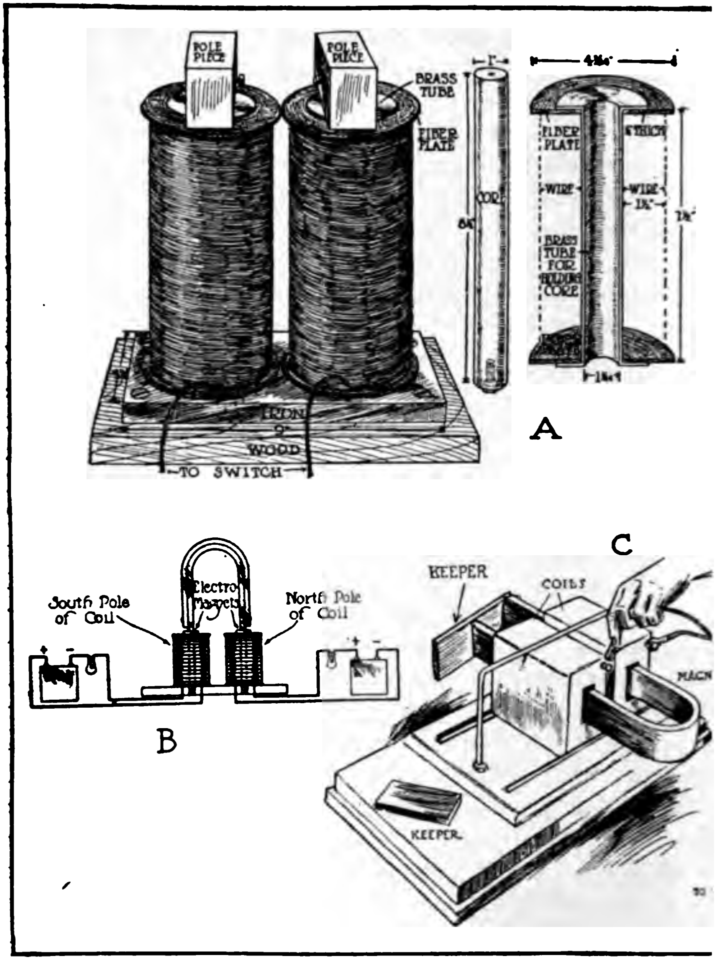


Fig. 263.—Defining Construction of Magnets for Remagnetizing M Field Members.

opposite way. Leave about 6″ of wire when starting to w coil in order to make a connection between them. After bo have been wound shellac them thoroughly and wind insulati over the outside. The cores are then fastened to the ir

plate, the coils are slipped over the cores and the pole pieces at tached to keep the coils in place. The view of the completed mag net is clearly shown in the assembly depicted at Fig. 263, A. Thi can only be used with 110 volts direct current.

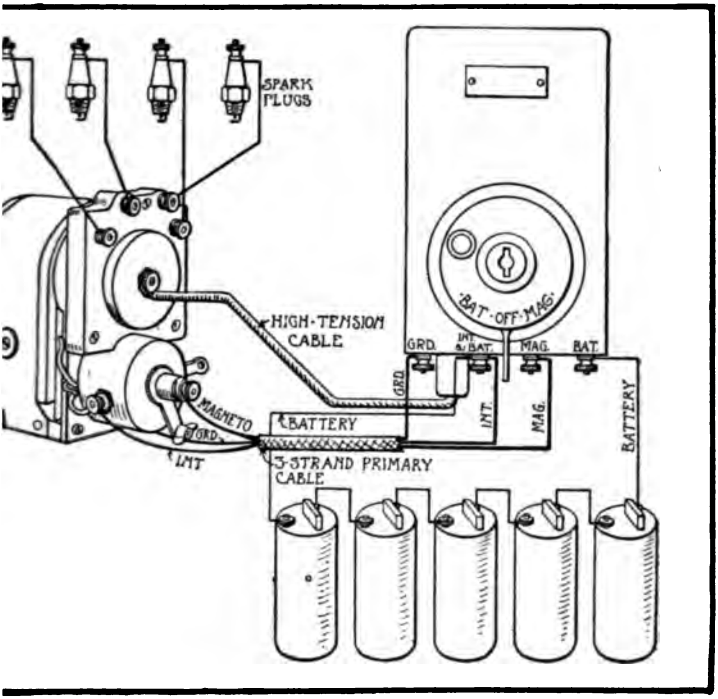
Before recharging the generator magnet it is important to tes the polarity of the electro-magnet, as the north pole of the magne to be charged must be brought in contact with the south pole o the electro-magnet and vice versa. It is not difficult to ascertai the polarity by using an ordinary compass or magnetic needle, th marked pole of which will point toward the north. Once th polarity has been determined the poles may be marked in any de sired way, usually by stamping the north pole N and the soutl pole S. Another magnet-charging device, which was described i the Commercial Motor, utilizes storage batteries as a source o magnetizing current. The magnets are composed of soft iron cor pieces about 6″ long and 1″ in diameter. The base is constructe of mild steel plate, the cores being fastened to the plates by screw or by turning down the end of the core and threading it to fit th hole in the base plate. Before screwing down the core pieces the are wound with No. 22 gauge insulated wire, the ends being lef free. The wires are connected up to a pair of storage batteries, a shown, and the latter are so connected up that the polarity of th soft iron cores are north and south respectively. Enough of th wire is wound on to have coils of about 2″ in diameter. If th core shows signs of overheating, low-voltage lamps should be place in the circuit to introduce some resistance. The voltage of the lam to be used depends entirely upon the voltage of the battery use to energize the magnet. It is stated that the magnets will b charged if they are merely placed in contact with the energize cores until they have absorbed sufficient magnetism to enable the to sustain a weight of 10 lbs. after which they are ready to b replaced on the magneto.

The illustration at C, Fig. 263, shows the Seanor garage mag net charging outfit, which is claimed to charge the magnet in on minute. From the exterior view of the device it will be eviden that it consists of a base upon which are mounted two solenoid coils carried *in square boxes.* The magnets to be charged are i

serted through the center of these coils during the energizi
process. In order to accommodate a horseshoe magnet of a
spread, one of the coil boxes is mounted so the distance between th
two openings is altered if desired. As ordinarily constructed, th
windings are wound for 6 volts and 20 amperes. In charging
magnet the ends of the horseshoe are brought up against an ir
core of the coil in such position that the magnet is attracted a
not repelled by the core. The magnet is then pushed through th
apertures in the centers of the coil boxes, taking the place of th
iron core, which is slowly pushed out. The current is then co
nected for merely the length of time required in touching one
the terminals of the wire to the binding post two or three times.
keeper is then laid across the part of the magnet arch which pr
jects beyond the coil boxes, and with the keeper still in place
magnet is replaced on the magneto. It is stated that a fre
charged Tungsten steel magnet of a large magneto will lift in
neighborhood of 20 lbs. as ordinarily energized by the ma
manufacturer. It is stated that with this device the magnet
can be increased to 30 lbs., which, of course, means a stronger
netic field when reassembled on the magneto.

Transformer Coil Magneto Systems.—Methods of wiring ty
cal transformer coil magneto systems are shown at Figs. 264 to
inclusive. At Fig. 264 all the parts of a system of this nature
clearly shown, and the wiring may be readily traced from the m
neto or battery to the coil. It will be apparent that at the bot
of the single unit coil there are four primary terminals and
secondary terminal. A high tension cable runs from the sec
ary terminal, which is protected by an insulating member to
central distributing terminal on the face of the distributor.
terminal marked "Bat." is attached to the carbon of a 5 dry-
battery, while the zinc terminal of the series is connected wi
terminal marked "Int." and "Bat." From this same termi
wire runs to the terminal on the side of the contact breaker.
terminal on the face of the contact breaker is coupled to the
terminal marked "Mag." A terminal on the coil marked "G
is attached to the grounding terminal on the magneto co
breaker. With this system, when the switch lever is pushed

side marked "Bat.," the current from the dry cell battery 'eyed to the magneto interrupter, from which it is led to the ·y winding of the coil. The secondary current is distributed ans of the magneto distributor to the spark plugs in proper order. When the switch lever is shifted to the other side



64.—Typical Transformer Coil Magneto Ignition System for Four Cylinder Engines.

switch, which is marked "Mag.," the current for ignition is d from the magneto armature instead of the battery.

) of the Splitdorf ignition systems are shown at Fig. 265, A being used in connection with a round type dash coil, hat at B is employed with a square type dash coil. The A has but six terminals, that at B has seven terminals. In

the coil at A the center terminal is used for the high tensi
rent and is connected to the central terminal of the magn
tributor. Terminal A of the coil runs to terminal A on tl
neto contact breaker face. The wire marked "2" runs
terminal on the side of the contact breaker. A wire joins t
"3" on the coil with the grounding terminal "3" on the m

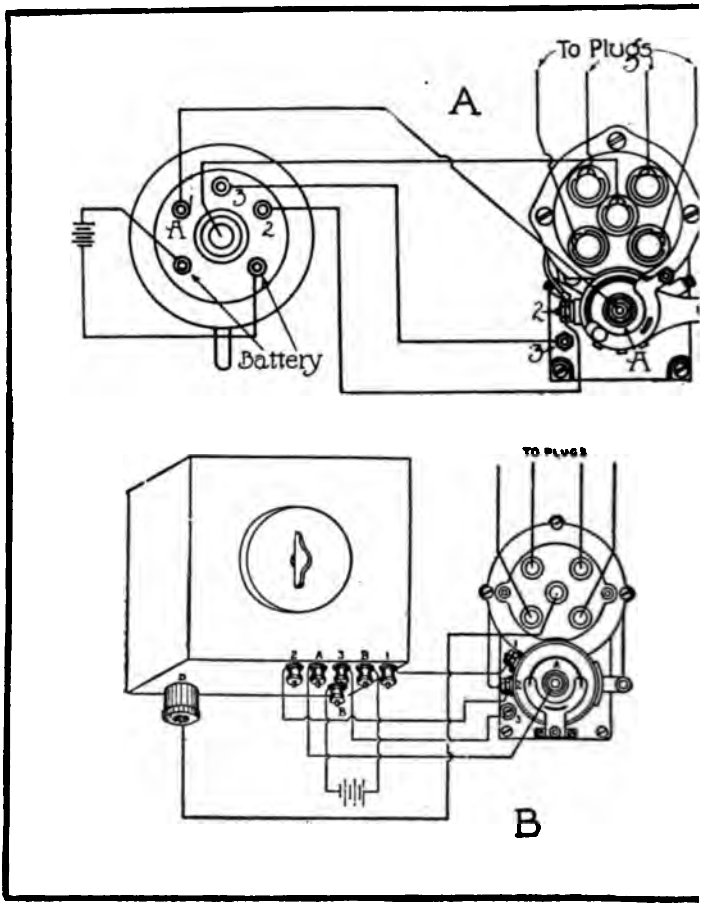


Fig. 265.—Wiring Diagrams, Showing Application of Splitdorf former Coil Magneto System.

The two remaining terminals of the coil, which are below the s ondary terminals, are joined to the battery, which is conventi alized for the sake of simplicity. In the system shown at F 265, B, the terminals on the magneto and those on the coil are li wise numbered, and there should be no difficulty in tracing th and making the proper connections if this diagram is used as guide.

The Remy transformer coil system is shown at Fig. 266, the a pearance and dimensions of the dash coil and the method of inst lation are clearly shown at A. It will be observed that at one e of the coil there are two terminals, one marked "Bat.," the otl "R.," which are wired to the dry cell battery, as shown. On t back of the coil is the secondary terminal, clearly outlined at which runs to the center of the distributor. The magneto sho is intended for six cylinder ignition and therefore has six distrib ing terminals, to be connected with an equivalent number of spa plugs. In order to simplify the wiring when the Remy system employed, the primary wire group, which consists of three wir has the insulation of each conductor a different color. One is y low, one green, and the remaining one red. The red wire, which attached to the grounding terminal on the magneto base, goes the center terminal on the side of the coil that has the three p mary terminals and which is shown at B. This would be the rig side if viewed from the front, while the battery terminals are the left side, if the coil is looked at from the switch end. The y low wire is connected to the contact screw on the breaker box a goes to the terminal on the side of the coil nearest the dash. T green wire runs from the screw on the magneto base to the rema ing terminal on the coil.

Dual Magneto Systems.—When the high tension magneto w first introduced it was looked upon in some quarters by conser tive manufacturers and motorists with some degree of suspicion, its reliability had not been thoroughly established. Sometimes di culty was experienced in starting a large engine directly from t magneto because it could not be turned over fast enough with t hand crank to turn the magneto armature at sufficient speed produce a strong spark. In order to provide an emergency s

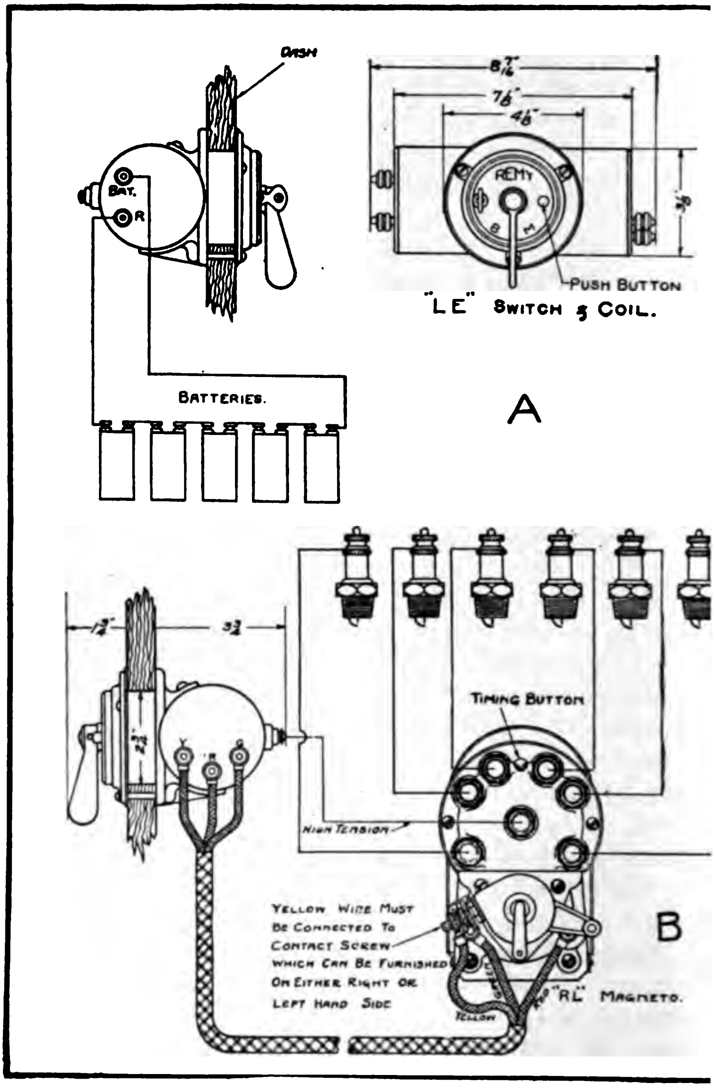


Fig. 266.—The Remy Ignition System.

tem of ignition and one that could be used for starting, the ma ers of high tension magnetos evolved what are termed "dual sy tems." The magneto utilized is practically the same as that us in the simple high tension systems, except that the contact break had a battery timer added which was used to interrupt a batte current. The reason for adding the battery timer and not using t magneto contact breaker was that a short contact was necessary obtain satisfactory operation from batteries, which the regul magneto contact breaker did not furnish. As the writer has pr viously explained, the points of a magneto contact breaker are ke in contact until interrupted by the cam. If these were used on battery the current would be flowing through them all the tin they were in contact, which would produce current waste. Wi the battery timer incorporated on the contact breaker the circuit established only at the instant the spark is needed in the cylind The systems shown at Fig. 267 are of Simms design, the only d ference being in the number of terminals provided on the co In the system at A four terminals are used. In that at B, but thr are employed. The only difference in the wiring is the connectio of the battery terminals. On the four terminal coils two of the are joined to the battery. On the three-terminal coil the wire th runs to point 1 of the magneto, as shown at B, also is joined to t positive terminal of the storage battery.

The Bosch Dual system, which is shown at Fig. 268, has s terminals on the back end of the coil. The coil is attached to t dashboard, as indicated, in the upper right hand corner, and ca ries the switch and the starting button on its face. The coil is the vibrator type. The terminals are all numbered and the wiri may be readily traced, as the points to which they connect on t magneto are numbered to correspond. In this system, instead using the usual high tension pencil connecting the collector bru to the center of the distributor, the high tension brush terminal is joined to a terminal on the spark coil, while terminal 4 of t spark coil is joined to the central distributing brush 4 of the ma neto. Terminal 6 of the coil is grounded, terminal 5 of the c runs to one of the battery terminals, the other one being grounde This leaves terminals 1 and 2 on the coil, No. 1 being connected

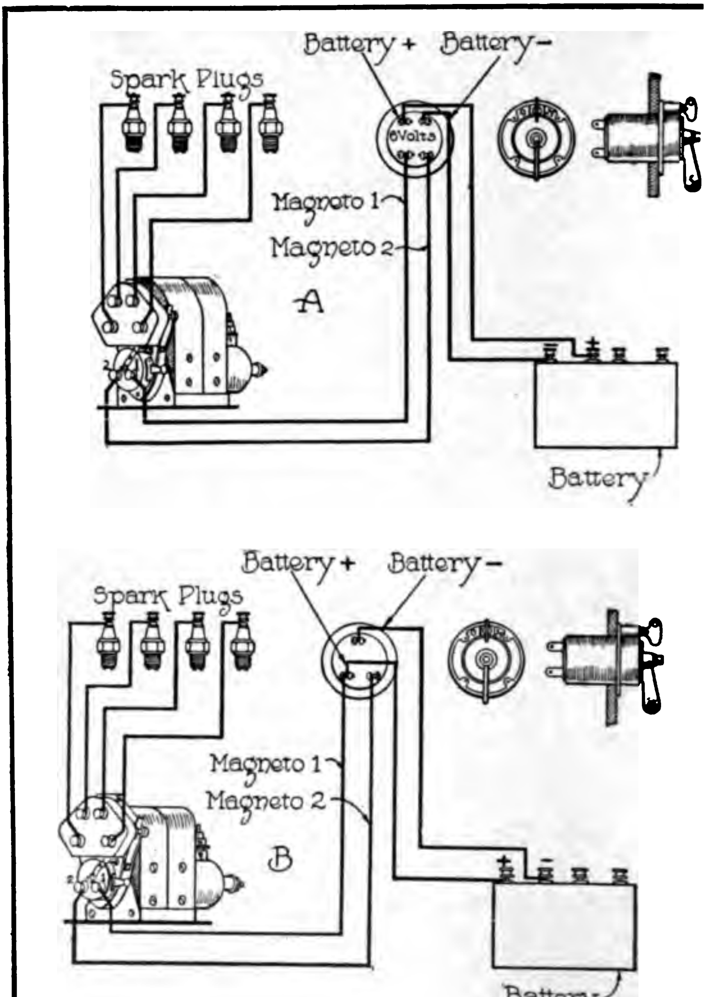


Fig. 267.—Wiring True High Tension Magneto to Obtain Dual System.

a terminal at the side of the battery contact breaker, while termin No. 2 attaches to a terminal on the side of the magneto conta breaker. With a system of this kind or with either of those show at Fig. 267, it is possible to short circuit the coil by pressing i on a starting button, which makes the vibrator buzz even if tl primary contact breaker on the magneto is not making contac This permits of starting the engine directly on the spark whe

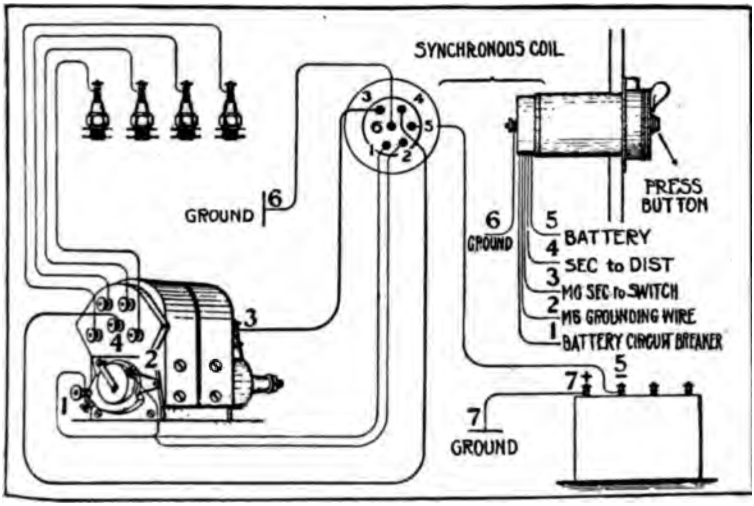


Fig. 268.—The Bosch Dual System.

they are of the four or six cylinder form, providing they have n been stopped long enough for the gas to leave the cylinders.

Master Vibrator Ignition Systems.—Practically the only c at the present time using the individual unit system of ignition the Ford, the complete wiring diagram of which is clearly show at Fig. 270, in the relation the parts actually occupy in the ca It will be observed that the induction coil has ten terminals, s of these being for the primary circuit and four for the secondai wires. The upper terminals of the coil are primary and run the timer segments. The four secondary terminals are connect to the spark plugs as indicated, while the remaining two terminal

which are at the bottom of the coil, are joined to th(terminal and to the battery respectively. In the systen each coil has a separate vibrator.

Many Ford cars have been supplied with what is kı master vibrator, which is a magnetic circuit breaker in perform that function for all of the coils. It is claimed vice of this character produces synchronism of the ignit

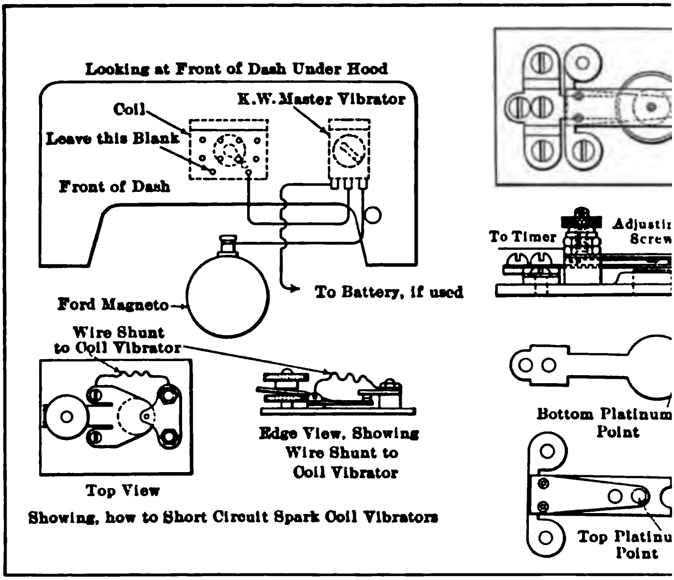


Fig. 269.—Method of Using Master Vibrator in Connection ı Unit Coil.

which is not possible to obtain where four separate vib: used on account of some of these being tuned up faster others. It is contended that this makes a smoother-runni and one delivering more power. A master vibrator uni joys wide sale is of K-W manufacture and is designed esp(use with Ford cars. The method of wiring the vibrator outlined in the upper left hand corner at Fig. 269. **As** *tor unit* carries a switch on its face, it has three **termin**

bottom, the center one of which is connected to one of the regular terminals of the spark coil, leaving the other one blank. One of the outside terminals of the master vibrator is coupled to the magneto, the other to a battery. The switch of the main coil is used only on one contact button, and may be left on that button, as the battery or magneto may be thrown in circuit at will by the switch

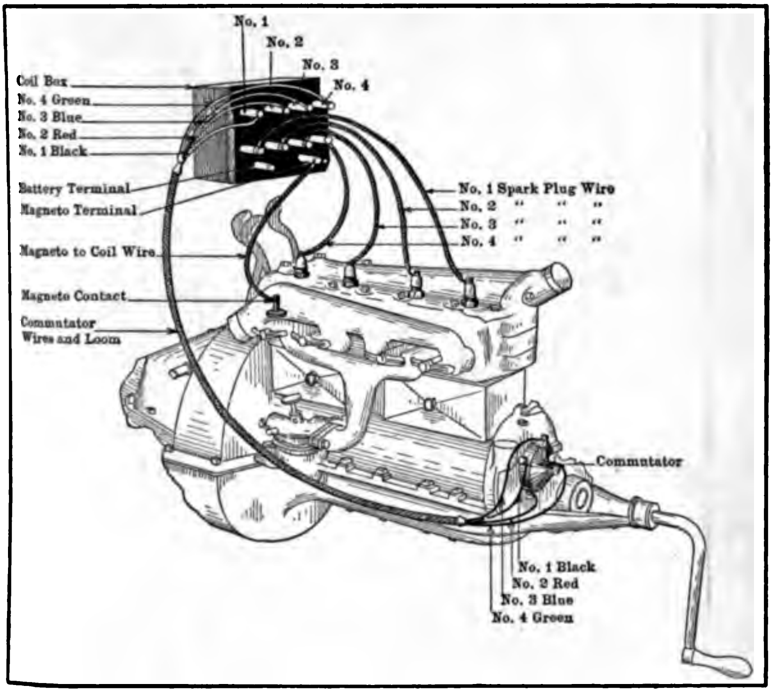


Fig. 270.—The Ford Ignition System.

on the master vibrator coil. It is necessary to short circuit the regular vibrators in order to put them out of commission. This is done by running a wire between the vibrator springs and the bridge carrying one of the contact points, as shown at the bottom of Fig. 269. Another method of short circuiting the vibrator is to keep the points in contact by wedging a piece of wood, rubber or

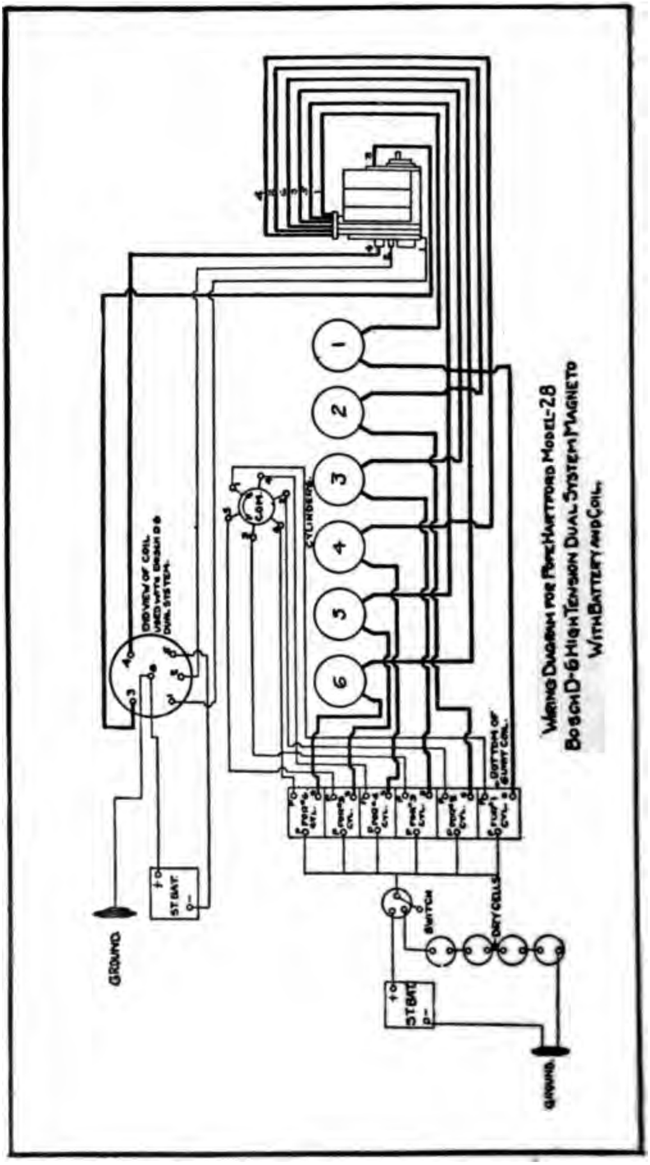


Fig. 271.—Wiring Diagram of Triple Ignition System Used on Six Cylinder Motor.

cardboard under the vibrator spring between the core of the coil and the vibrator. Keeping the points in contact in this manner is equivalent to short circuiting them by the wire shunt.

When but one vibrator is used the contact points must be made larger than those on the individual vibrators, because it does four times as much work. The construction of the K-W vibrator is clearly shown at Fig. 269, and in view of the instructions that have been previously given for the care and adjustment of these devices it is not necessary to describe its construction. The instructions given for adjusting the vibrator are very simple, it being merely necessary to observe if there is a space of $1/64$ inch between the platinum contact points when the vibrator spring is held down firmly on the iron core. A gauge made of $1/64$ inch thick steel may be placed between the contact points until the adjusting screw is screwed down to a point where the gauge can be pulled out without much trouble. This will give the proper distance for the armature or bottom spring to travel.

Double and Triple Ignition Methods.—There are many cars in operation to-day which utilize double and triple ignition systems. On some of these it is possible to have three practically independent means of supplying the ignition spark. As will be apparent, the wiring of a triple ignition system is apt to be much more complex than that of the simpler methods now in vogue. In the ignition system outlined at Fig. 271, which has been used on a six cylinder car, it will be evident that in addition to the usual Bosch D-6 dual magneto an entirely independent individual spark coil and battery timer system is included. Two sets of plugs are used, one serving both magneto distributor systems, while the other is connected to the individual coil units. The connections of the magneto system are no different than in the regular dual system previously described, while those of the battery and coil may be easily determined by a close study of the diagram. The primary timer has six contacts, one of which serves each ignition coil. As the firing order of this engine is 1-5-3-6-2-4, the wires from the timer must run to the individual unit coils in the same order so as to have the cylinders fire in proper sequence. For example, the wire from the contact No. 1 of the timer runs to coil No. 1,

next in order is contact No. 5, which is wired to coil uni Following this comes timer contact No. 3, which supplies to coil No. 3. While the individual spark coils are conn order, i.e., coil No. 1 is joined to spark plug and cylinder N No. 2 to spark plug and cylinder No. 2, and so on the tin tact must be numbered according to the firing order. It apparent that two sources of ignition current are provided battery and coil systems, one being a storage battery, the set of dry cells.

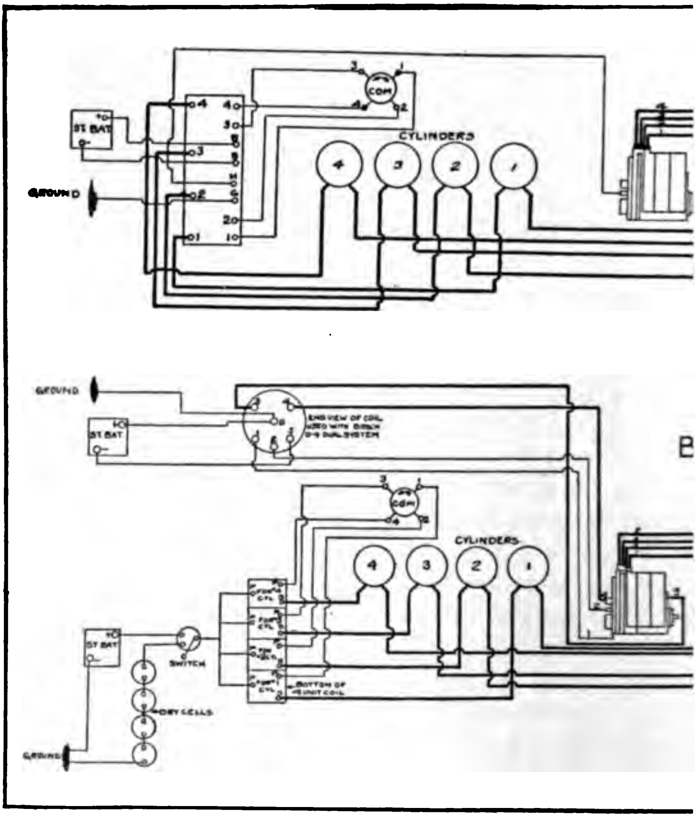


Fig. 272.—**Wiring Diagram of Double Ignition System at A; o**
Ignition System at B, both for Four Cylinder Engines.

A double ignition system in which a true high tension magneto is used and a four unit vibrator coil and four point timer is shown at A, Fig. 272. This ignition system is for a four-cylinder motor having a firing order of 1—3—4—2. At B, Fig. 272, a triple ignition system for a four-cylinder engine is shown, this being practically the same as that outlined at Fig. 271, except that the wiring diagram is somewhat simpler owing to the lesser number of cylinders. The advantage of a double ignition system is that one can determine if irregular engine operation is due to the ignition system or not very easily by running the engine first on one system, then on the other. If the engine runs as it should on the battery system after it has been misfiring on the magneto it is reasonable to assume that some portion of the magneto system is not functioning properly. If the engine runs well on the magneto, but not on the battery, the trouble may be ascribed to failure in the chemical current producer or its auxiliary devices. On the other hand, if the engine does not run well on either ignition systems, it is fair to assume that the trouble is not due to faulty gnition.

Two Spark Ignition.—Most racing and a few pleasure cars have been equipped with two spark magneto ignition systems, the dea being to secure greater power and speed due to the use of wo spark plugs in the cylinder. While systems of this kind are are, it may be well for the repairman to become familiar with the principles involved in case he should ever be called upon to install a two spark magneto or to make repairs on some speedster model o equipped. When a magneto is employed in connection with two park ignition it is common practice to provide two separate disributors and in some cases a double wound armature having two ets of windings served by a common contact breaker. In the ystem shown at A, Fig. 273, a two spark magneto is employed n connection with the simple dash switch wired as indicated, by which one may obtain the use of but one spark with the switch ever in the position shown and the double spark if the switch lever s rocked to the other extreme, or on the line marked "2." If he lever is swung to the left or on a line with that indicated 'O," no spark will pass through the engine, as the magneto will

be grounded. The system outlined at B is that of a tw
magneto that can be used in connection with a vibrator
battery, as in the dual system previously described. In
to the switch on the coil, a two point switch is placed on t
in order to obtain single or double spark ignition as desi

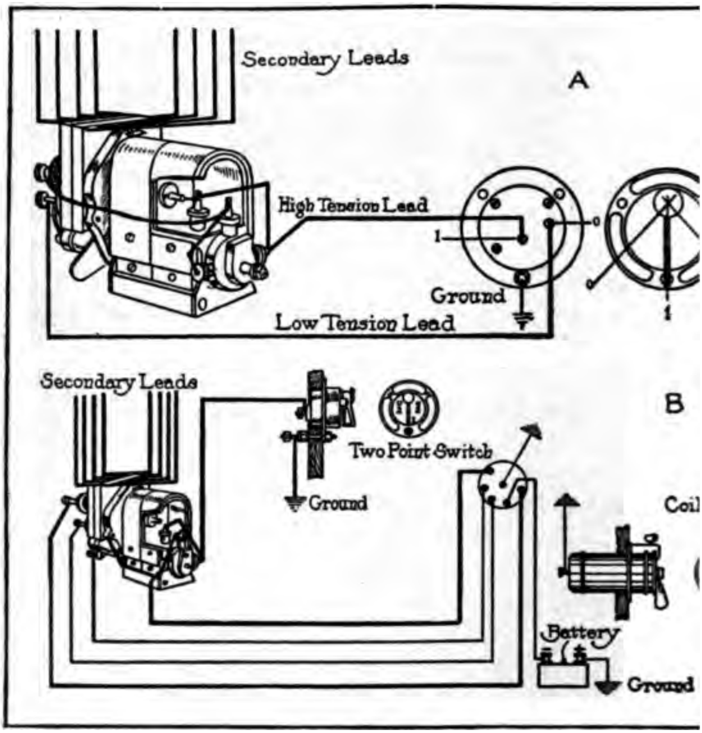


Fig. 273.—Outlining Use of Two Spark High Tension Magnet

Timing Battery Ignition Systems.—In timing a motor
battery ignition system with individual vibrator coils to
the current to respective cylinders, the first thing to asce
the firing order of the engine to be timed. The diagram, F
shows all components of a battery ignition system, also a s
view of one of the cylinders of the engine, showing the

of the piston when the spark should occur in the cylinder with the primary timer fully advanced. When the primary timer is fully retarded the spark will take place after the piston has reached the top of its stroke and has started to go down on the explosion stroke. The four unit spark coil has a two point switch on its face and has ten terminals. Four of these which are protected by heavy insulators or bushings of hard rubber run to the spark plugs as indicated. These are the secondary terminals. The two primary terminals under the switch are connected to the positive poles of the dry cell and storage batteries respectively, the negative terminals of the two batteries being joined together by a common wire and grounded. This leaves four primary leads which go to insulated terminals connecting with the segments of the timer.

The method of timing an engine is very simple. The spark advance lever on the steering wheel is advanced fully. The inlet valve of cylinder No. 1 is watched as the engine is turned by the hand crank. Just after the inlet valve closes which indicates that the piston has started to go up on its compression stroke the piston travel may be gauged accurately as it moves up by the timing rod inserted through a petcock in the top of the cylinder or through a valve cap opening. If the engine is not provided with a relief cock or spark plug that will permit the use of the gauge rod, the flywheel markings may be utilized to determine the center corresponding to the end of the piston upward movement. The vibrator of coil connected to cylinder No. 1 should begin to buzz with the timer casing in full advanced position before the piston reaches the end of its upward stroke. The amount of crankshaft travel is about 30 degrees from the point where the spark takes place to that where the piston reaches the top of its stroke. If the timer casing is set in full retard position the spark should take place 30 degrees of the crankshaft travel after the piston has left the end of its compression stroke. Some engines have the spark set 45 degrees advance. With the spark advance lever set about half way of its travel the spark may be made to occur just when the piston reaches the end of its compression stroke, or on top center. It is necessary to provide a wider range of spark advance on a

battery and coil ignition system than when a magneto is it is said that a range of advance of 60 degrees is suffic four-cylinder motors and 27 degrees for six-cylinder motc magneto ignition.

In timing a strange car it is easy to tell whether the m of the spark lever advances or retards the timer case by

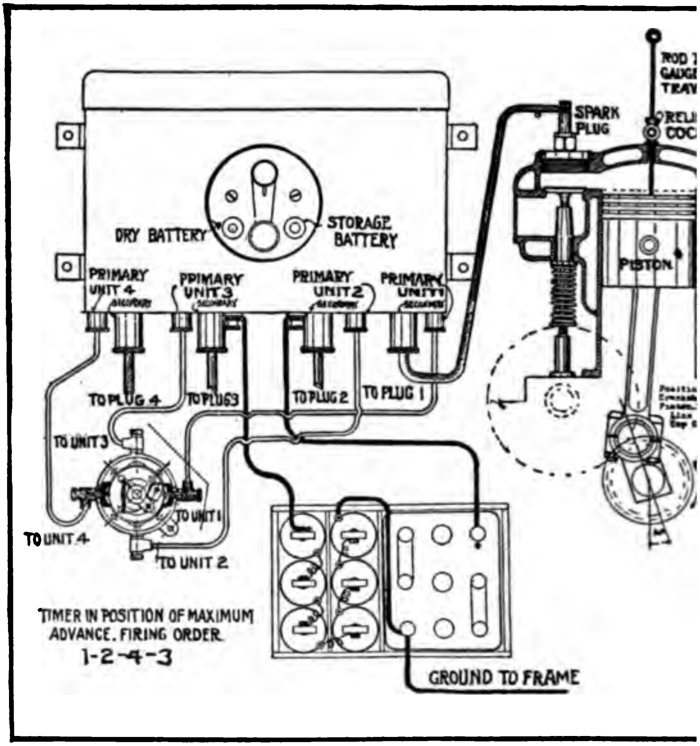


Fig. 274.—Diagram Showing Method of Timing Four Cylinder Ignition System.

the direction of movement of that member. If the spark lever is pushed in a certain direction, say from the point *sector* nearest the driver to the other extreme, and the s *on the timer* move to meet the advancing contact roller, i

dent that a movement of the spark advance lever from front rear advances the ignition. If the timer case oscillates so t segment moves away from the advancing contact roller, that mov ment of the spark lever retards the ignition. In most timers t rotating contact member is fastened to the shaft in such a wa that it may be moved independent of engine rotation, if desire by releasing the fastening. Sometimes it is held on a taper shaft by a clamping nut, in other constructions it is driven by hollow shaft which is set screwed to the timer driving shaft t position of which can be changed as desired. In every case t roller should be set in contact with the segments joined to c unit No. 1, the remaining terminals being wired according to t firing order and the direction of rotation of the timer brush. the diagram now under discussion after the roller leaves unit No. segment it will go to that in connection with unit No. 2, then the one joined to unit No. 4, and finally to the terminal conveyi the electrical current to unit No. 3. This means that the plug cylinder No. 1 fires first, followed by those in cylinders 2, 4, in the order named. With the switch lever in the position shov or between the two contact buttons, the ignition is interrupt and battery current cannot flow to the coil unit. If the swit lever is moved to the button on the right marked "storage ba tery," the secondary current producer will furnish ignition. moved to the button on the left, the dry cells will be brought in action. The same method is employed in timing a two, three six-cylinder motor, the only precaution to be observed being run the wires from the timer to the coils so the cylinders will fi in proper order.

At one time secondary distributor systems using a single ur vibrator coil for firing a multiple cylinder engine were very pop lar, but at the present time few cars use the long contact tim and distributor combination. The modern cars that employ batte ignition use a short contact timer and a non-vibrator coil un Popular systems of this nature are the Atwater-Kent and t Delco, both of which have been previously described. Practical the same method of timing is employed with these systems exce that there is but one primary terminal on the contact breaker po

tion of the distributor which is joined to the corresponding minal of the spark coil. A proper distribution of current to cylinders is made by connecting the distributing terminals to plugs in proper firing order, same as advised with a magneto.

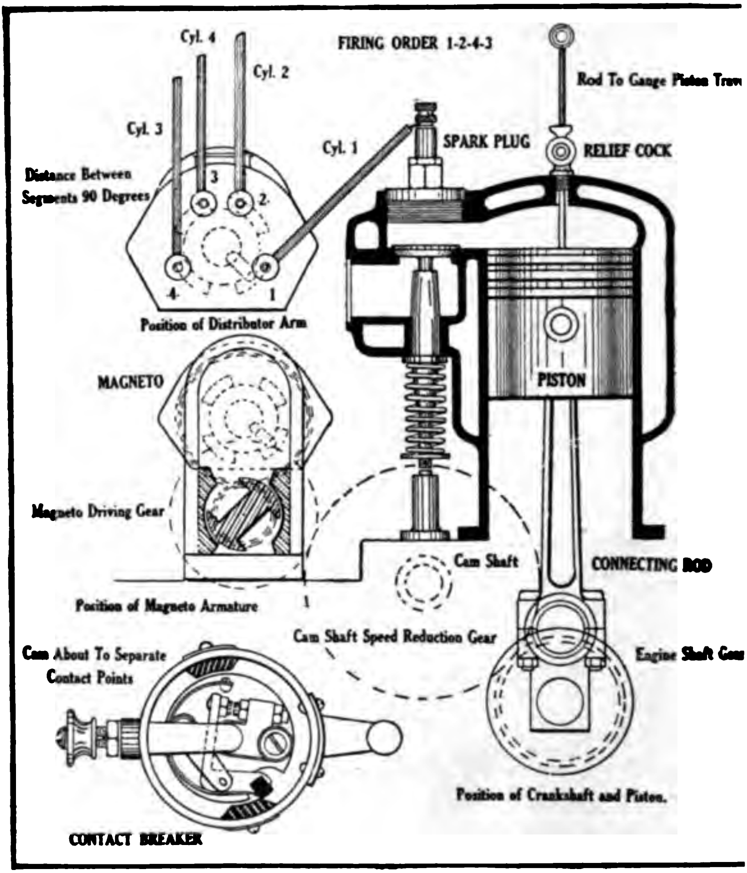


Fig. 275.—Diagram Showing Method of Timing Four Cylinder H Tension Magneto Ignition System.

Timing Magneto Ignition Systems.—An ideal method of neto placing and one followed by a large number of manufactu

shown at Fig. 275. In this the device is fitted to a four-cylinder gine, and as the armature must be driven at the same speed as e crankshaft, it is necessary to use but one extra gear, that being e same size as the engine shaft pinion and driven by the cam-aft speed reduction gear. Incidentally, the sketch illustrates the t method of timing the magneto, which is one of the direct h-tension type. The position of the various parts is clearly own. Having fixed the magneto to the engine crankcase, the iving pinion, or one of the members of a flange or Oldham upling, is put loosely on the tapered end of the armature shaft, d the cover to the distributor and the dust cover of the contact aker are removed to allow one to control the position of the nature. The motor is now turned over by hand so the piston the first cylinder is at top center, which can be determined her by watching the crankshaft through a suitable opening in engine base, by reading the marks on the flywheel rim, or by erting a wire through a compression relief petcock or spark g hole, if either of these is at the top of the cylinder.

The armature of the magneto is then brought to the position licated in sketch, which represents the fitting of a magneto t is turning clockwise when viewed from the driving end. The tance between the end of the armature and the pole piece should between 14 and 17 mm or between .5511 inch and .6692 inch. s represents an advance of about .5 inch on a motor with a five-h stroke. A graphic chart, prepared by the Bosch Company reproduced at Fig. 243, shows the relation between piston vel and crankshaft movement for engines of different strokes y clearly. The armature is uncovered by removing the flat ing cover lying between the horseshoe magnets, this often carry-the safety spark gap (as shown at Figs. 256 and 258), and mally serving as a lid. If earlier timing be desired for any ial purpose the gap may be widened a trifle, if it be thought timing is too far advanced, the gap may be lessened. The tact breaker is fully advanced at this time and the contact ts are just about to separate. Having placed everything in tion as described, tighten the coupling on the taper shaft and out for a small taper pin.

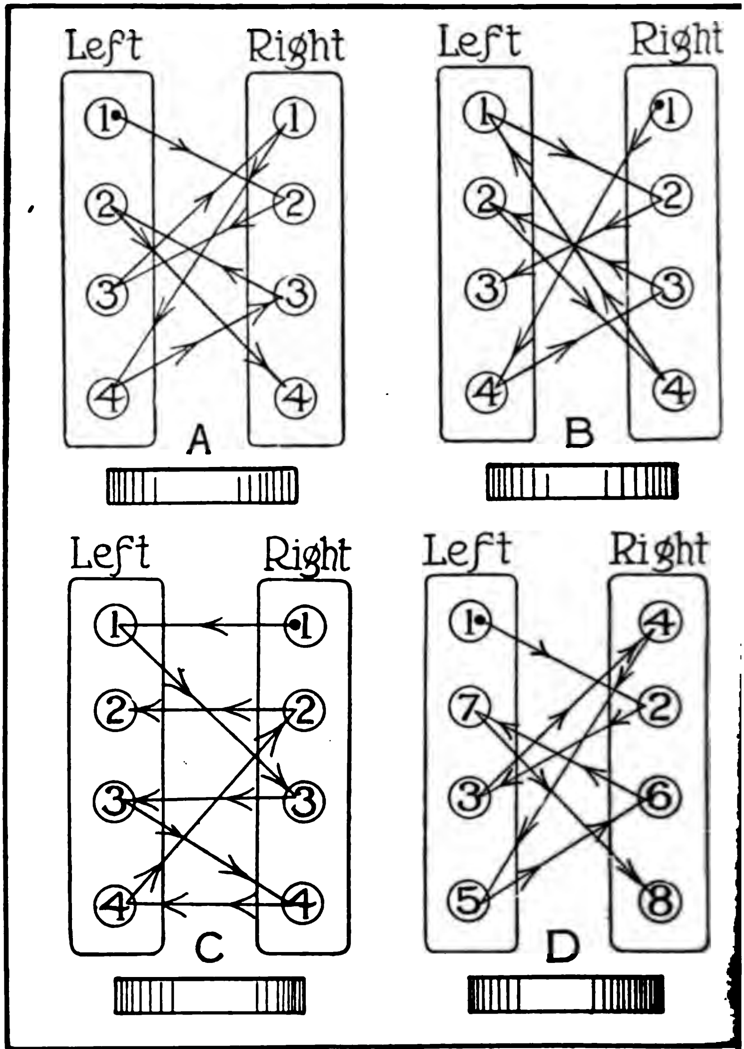
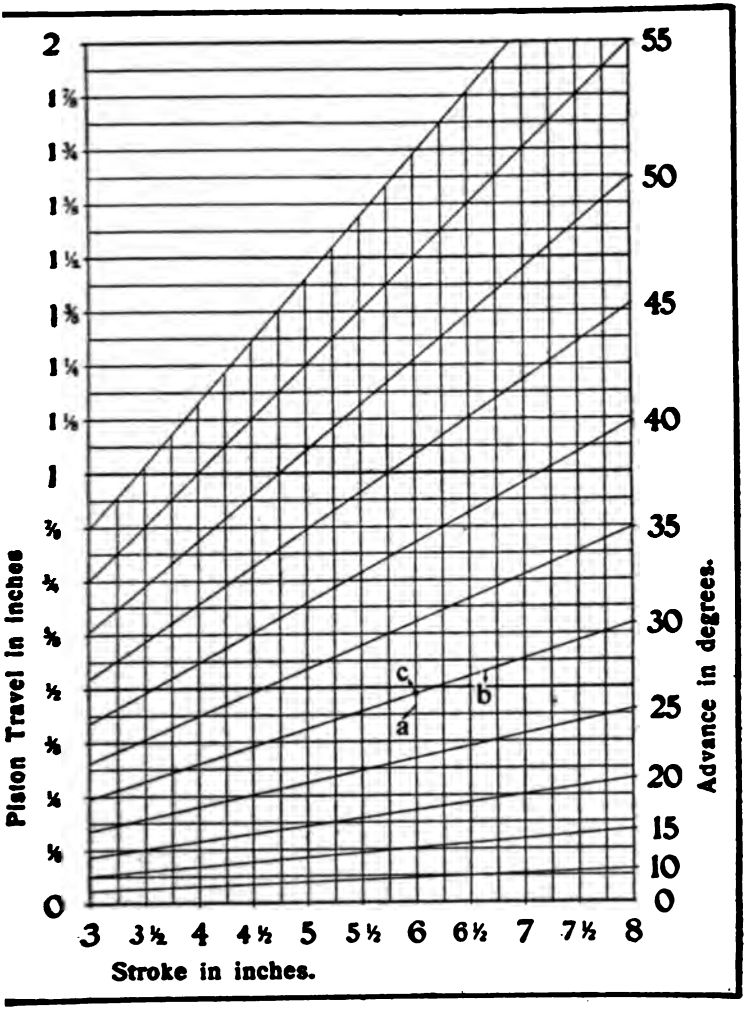


Fig. 276.—Firing Orders of Typical Eight Cylinder V Engines.



ig. 277.—Chart Showing Piston Travel to Correspond to Different Degrees of Spark Advance for Motors of Various Strokes.

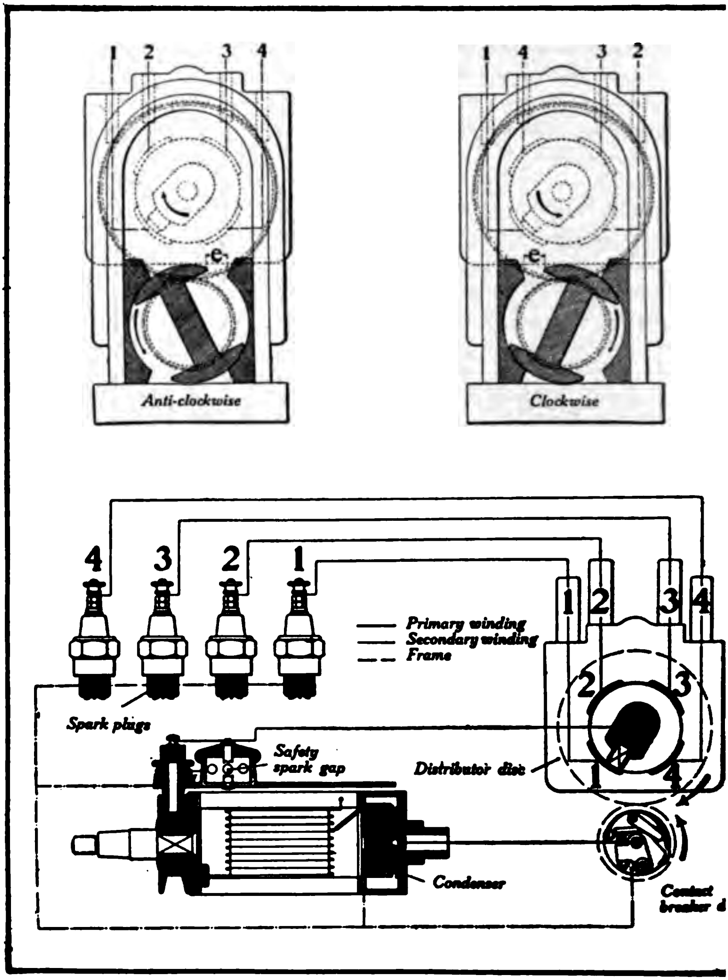
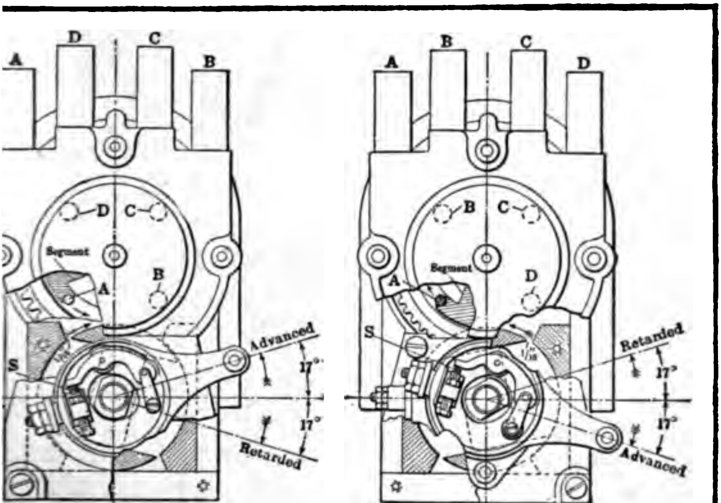


Fig. 278.—At Top, Showing Methods of Timing Bosch High Te Magneto when Rotated in Either Direction. At Bottom, Simpl Wiring Diagram of Bosch High Tension Ignition System.

e connections to the various cylinders must be made in the they fire (see following tabulation). When the cover to the utor is off, see at which segment the brush is contacting. ire to the spark plug in the first cylinder is then led to the ıal corresponding to this segment. Then the plug in the er that is next to fire is coupled to the next segment, and The numbers on the distributor show the order in which



Left Hand Magneto.
king at Machine from Driving
. Points (S) about to Open as
ature Core leaves Pole Piece
t 1/16", Segment just under Brush.

Right Hand Magneto.
Looking at Machine from Driving
End. Points (S) about to Open as
Armature Core leaves Pole Piece
about 1/16", Segment just under Brush.

Fig. 279.—Showing Methods of Timing Splitdorf Magneto.

rious contacts are brought in contact with the rotating dis- ng brush, and not that in which the cylinders fire. In the the cylinders fire 1—2—4—3. Therefore, the segment num- is coupled to the plug in cylinder 4, and the segment 4 is ted to the plug in cylinder 3, which is thus the last to fire explosion takes place first in cylinder 1. The direction of tributor brush rotation, if driven by the usual form of gear-

ing, is opposite to that of the magneto armature. Obviously, i one cylinder is timed correctly, the remaining members will als fire at the proper time in the cycle of operations. The position of the armature, distributing brush, contact breaker cam an piston are easily ascertained by inspection of drawing.

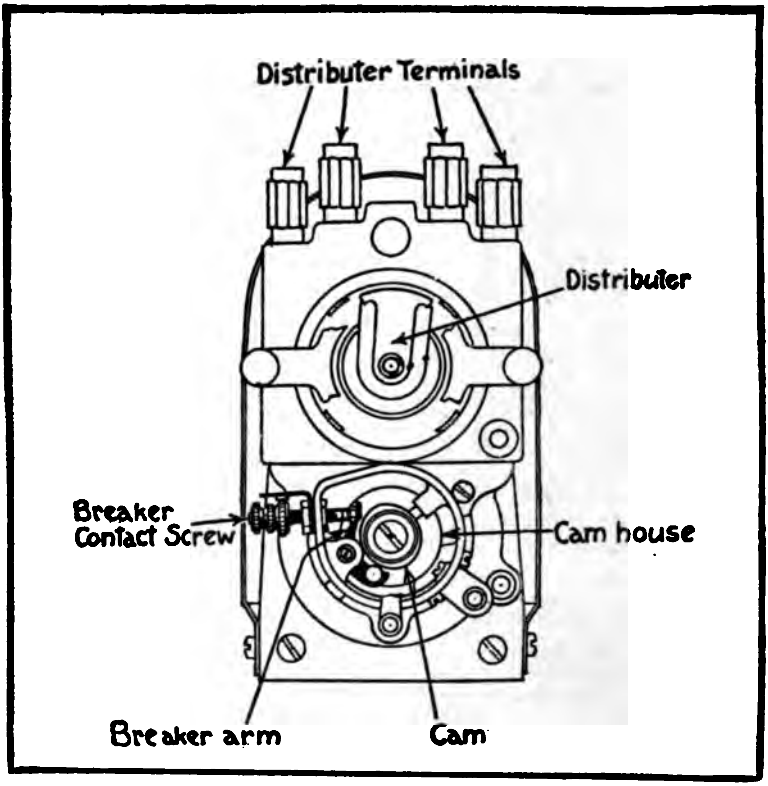


Fig. 280.—Front View of Remy Magneto, Showing Construction of Distributor and Contact Breaker.

Firing Order of Typical Engines.—The following informatio relative to timing of leading 1914 and 1915 models of America manufacture will prove of great value to the repairman called upon to repair many different makes of cars. It is well to remem-

er, if the firing order is not known, that it can be easily determined y following the inlet valve movements in the cylinders and noting e order of opening of these members.

ABBOTT-DETROIT.

34–40 AND 44–50—FIRING ORDER 1–3–4–2.

BELLE ISLE—FIRING ORDER 1–5–3–6–2–4.

Magneto Setting—Piston dead centre, lever fully retarded. Full advance, park occurs with crankshaft 13 degrees ahead of dead centre. Contact int gap .018 inch.

ALLEN.

40—FIRING ORDER 1–2–4–3.

Magneto Setting—Piston top dead centre, lever fully retarded.

AMERICAN.

SCOUT—FIRING ORDER 1–3–4–2.

644, 646 AND 666—FIRING ORDER 1–5–3–6–2–4.

Magneto Setting—Three-quarter inch after dead centre on flywheel.

ARBENZ.

FIRING ORDER 1–3–4–2.

Magneto Setting—Piston .03125 inch late, lever fully retarded.

AUBURN.

4–40 AND 4–41—FIRING ORDER 1–3–4–2.

Magneto Setting—Piston .03125 inch late, lever fully retarded.

6–46 AND 6–45—FIRING ORDER 1–4–2–6–3–5.

Magneto Setting—Piston top dead centre, lever fully retarded.

BUICK.

B 24, 25, 36, 37 AND 38—FIRING ORDER 1–3–4–2.

Delco—With timer cam fully retarded, spark occurs 40 degrees past er dead centre on firing stroke. With hand spark lever half-way ad-ced, spark occurs at approximately top dead centre.

B 55—FIRING ORDER 1–4–2–6–3–5.

elco—Piston dead centre with timer fully retarded.

CASE.

25 R AND 35 S—FIRING ORDER 1–3–4–2.

Magneto Setting—One thirty-second inch before top dead centre.

40 O—FIRING ORDER 1–3–4–2.

Magneto Setting—One-sixteenth inch after top dead centre.

CHALMERS.

24—FIRING ORDER 1–4–2–6–3–5.

Magneto Setting—One and one-half inches past centre, lever fully tarded.

CHANDLER.

SIX—FIRING ORDER 1–5–3–6–2–4.

Magneto Setting—Piston dead centre, lever fully retarded.

COLE.

FOUR—FIRING ORDER 1–3–4–2.
SIX—FIRING ORDER 1–5–3–6–2–4.

Delco—Piston dead centre, distributor fully retarded.

CONTINENTAL.

27—FIRING ORDER 1–3–4–2.

Magneto Setting—Three-quarter inch after dead centre on flywheel

GLIDE.

36 AND 30—FIRING ORDER 1–3–4–2.

Westinghouse—Piston top dead centre.

GRANT.

M—FIRING ORDER 1–3–4–2.

Magneto Setting—Lever fully advanced, piston .3125 inch before dead centre.

HAYNES.

28—FIRING ORDER 1–3–4–2.

Magneto Setting—One sixty-fourth inch advanced on down stroke.

26 AND 27—FIRING ORDER 1–4–2–6–3–5.

Magneto Setting—One sixty-fourth inch advanced on down stroke.

HUDSON.

6–40 and 6–54—Firing Order 1–5–3–6–2–4.

HUPMOBILE.

32—Firing Order 1–2–4–3.

Magneto Setting—Piston dead centre, lever fully retarded.

IMPERIAL.

34 F B, 32 and 34 4 M—Firing Order 1–2–4–3.
54 and 44–6—Firing Order 1–5–3–6–2–4.

Magneto Setting—Points break with piston on dead centre.

INTER-STATE.

45—Firing Order 1–5–3–6–2–4.

JACKSON.

Majestic and Olympic—Firing Order 1–3–4–2.

Magneto Setting—Piston .125 inch before top centre.

Sultanic—Firing Order 1–5–3–6–2–4.

Magneto Setting—Piston .125 inch before top centre.

JEFFERY.

93—Firing Order 1–3–4–2.
96—Firing Order 1–4–2–6–3–5.

Magneto Setting—Piston dead centre, lever fully retarded.

KEETON.

F—Firing Order 1–5–3–6–2–4.

Magneto Setting—Points break 6.5 degrees before centre.

KING.

B—Firing Order 1–3–4–2.

Magneto Setting—Points break with lever fully retarded from centre .5 inch past on flywheel.

KNOX.

44 and 45—Firing Order 1–3–4–2.

Magneto Setting—Piston .75 inch before top centre, lever fully re- ed. Battery, piston .375 inch before top centre.

KRIT.

L—FIRING ORDER 1–3–4–2.

Magneto Setting—Piston .125 inch before top dead centre, lever f retarded.

LEWIS.

SIX—FIRING ORDER 1–5–3–6–2–4.

Magneto Setting—Piston top dead centre, lever fully retarded. advance equals .234375 inch of piston stroke.

LOCOMOBILE.

48 LD AND RD, 38 RD AND LD—FIRING ORDER 1–5–3–6–2–4.

Magneto Setting—Three-eighths to .4375 inch before top dead cei lever fully advanced.

LOZIER.

FOUR—FIRING ORDER 1–3–4–2.

77—FIRING ORDER 1–4–2–6–3–5.

Magneto Setting—Piston dead centre, lever fully retarded.

LYONS-KNIGHT.

K4—FIRING ORDER 1–3–4–2.

Magneto has six-inch range on 20-inch flywheel from one inch past ce to five inches before.

MAXWELL.

25–4 AND 35–4—FIRING ORDER 1–3–4–2.

50–6—FIRING ORDER 1–4–2–6–3–5.

Magneto Setting—Points break with piston on dead centre, lever f retarded.

MOLINE-KNIGHT.

26–50—FIRING ORDER 1–3–4–2.

Magneto Setting—Piston top dead centre.

MOON.

42—FIRING ORDER—1–3–4–2.

6–50—FIRING ORDER 1–5–3–6–2–4.

Delco—Spark breaks on centre in retarded position.

NATIONAL.

40—Firing Order 1–3–4–2.

Magneto Setting—Piston .0625 inch past top dead centre, lever fu retarded.

Six—Firing Order 1–5–3–6–2–4.

Magneto Setting—Piston .125 inch before top dead centre, lever fu retarded.

NORWALK.

C and D—Firing Order 1–4–2–6–3–5.

Atwater Kent—Piston is .093 inch past centre with distributor set retard.

OLDSMOBILE.

54—Firing Order 1–5–3–6–2–4.

Delco—Spark occurs at piston dead centre with hand spark lever fu retarded or .390625 before dead centre with lever fully advanced.

OVERLAND.

79—Firing Order 1–3–4–2.

Magneto Setting—One and one-quarter inches after dead centre (1 wheel), lever fully retarded.

PACKARD.

2–38—Firing Order 1–4–2–6–3–5.

Magneto Setting—Piston .5 inch before top centre, lever fully advanc

PAIGE.

25 and 36—Firing Order 1–3–4–2.

Magneto Setting—Place No. 4 piston on top dead centre (Compressi stroke). Points should just begin to break.

PIERCE-ARROW.

Sixes—Firing Order 1–5–3–6–2–4.

Magneto Setting—Magneto mark on flywheel should be 4.8125 incl ahead of 1 and 6 top centre and 1 showing in timing window. Piston .5 inch before top dead centre of 33 degrees of crank circle. Batt spark occurs with piston 2.125 inches before top dead centre or 75 degr of crank circle with spark lever fully advanced.

PILOT.

50—Firing Order 1–3–4–2.
60—Firing Order 1–5–3–6–2–4.

Magneto Setting—Points break with lever fully retarded and piston dead centre.

POPE-HARTFORD.

35—Firing Order 1–2–4–3.

Magneto Setting—Piston top dead centre. Maximum advance of mag .5 inch on piston travel.

PREMIER.

6–48 and Weidely—Firing Order 1–4–2–6–3–5.

Magneto Setting—Piston dead centre, lever fully retarded.

REGAL.

C, T, N and NC—Firing Order 1–2–4–3.

Magneto Setting—Piston top dead centre, lever fully retarded.

REO.

Fifth—Firing Order 1–3–4–2.

Remy System—Piston top dead centre when indexing button on di butor engages.

SAXON.

A—Firing Order 1–3–4–2.

Atwater Kent—Piston dead centre, distributor fully retarded.

SIMPLEX.

38 and 50—Firing Order 1–3–4–2.

Magneto Setting—Piston .015625 inch before top dead centre.

75—Firing Order 1–3–4–2.

Magneto Setting—Piston dead centre or slightly after.

SPEEDWELL.

H—Firing Order 1–5–3–6–2–4.

Magneto Setting—Points break with piston at top dead centre.

Rotary—Firing Order 1–5–3–6–2–4.

Magneto Setting—One-sixteenth inch after top dead centre, lever f *retarded.*

STEARNS-KNIGHT.

FOUR—FIRING ORDER 1–2–4–3.
SIX—FIRING ORDER 1–5–3–6–2–4.

Magneto Setting—Piston top dead centre, points breaking.

STEVENS-DURYEA.

C 6—FIRING ORDER 1–4–2–6–3–5.

Magneto Setting—Figure 1 showing in timing window, 25 degrees before top dead centre (flywheel).

STUDEBAKER.

FOUR—FIRING ORDER 1–3–4–2.
SIX—FIRING ORDER 1–5–3–6–2–4.

Remy System—Spark occurs .75 inch after top dead centre.

VELIE.

5 AND 9—FIRING ORDER 1–3–4–2.
10—FIRING ORDER 1–5–3–6–2–4.

Magneto Setting—Piston top dead centre.

WINTON.

SIX—FIRING ORDER 1–5–3–6–2–4.

Magneto Setting—Piston .125 inch after top dead centre, lever fully retarded and points breaking.

Battery System Hints.—See that the wires are heavy enough to carry the current and that all the connections are kept clean and bright as every corroded joint causes needless resistance.

Inspect battery connections, etc., occasionally, as they have a habit of working loose.

Look well to the ground connection, which should be very securely made and placed where it will not corrode.

Be sure the battery, especially if dry cells are used, is where it cannot get wet, as the paste-board may absorb sufficient moisture to short circuit the cells.

See that all wires are securely fastened so that they cannot by any means rub or chafe against either wood or metal parts; especially the secondary wires.

Frequently examine the condition of the plugs, as plug trc is often looked for elsewhere.

Don't allow the wires to become water- or oil-soaked, as s circuiting will probably result.

Don't screw down electrical connections with the fingers, tight joint cannot be made. Use pliers.

Don't allow the storage battery to get so far discharged it will not operate the coil. See that the vibrators are set as lig as possible to run the engine without skipping, otherwise they waste current.

Don't take it for granted you have ignition trouble every the engine stops.

Don't start out knowing the battery to be nearly exhau as it may run all right to start with, but will probably go ou business at a most inopportune time and place.

Don't adjust the coil vibrator for the biggest possible sp as it wastes current.

Don't think the coil is no good if the vibrators do not exactly alike.

Don't test storage batteries with an ammeter unless they charging or discharging.

Don't strain the coil by disconnecting the secondary wires pletely so that no spark can jump, or by testing how far it jump.

Don't screw or nail anything on to the coil box, as you injure it.

Don't tolerate any loose wires or poorly made connections. them at once.

CHAPTER VI

MOTOR STARTING AND LIGHTING SYSTEMS

Leading Methods Outlined—Mechanical Starters—Pneumatic Starters—P to-lite Primer—Electric Starter Forms—Generator and Starting Mot —Generator Driving Means—Starting Clutches and Gearing—Switc and Current Controlling Devices—Typical Wiring Diagrams—Delco S tem—Bijur—Hartford, Auto-Lite—Gray & Davis—Chalmers—Ent Remy—Faults in Motors and Generators—Faults in Wiring—Typi Lighting Systems.

ONE of the pronounced developments of the last two or th years has been the general adoption of various starting means setting the engine in motion without recourse to the usual fo of hand crank. Some of these motor starting systems merely place the usual hand crank with some means of turning the mo over without leaving the seat by purely mechanical connectio Others, on 1912 and 1913 models of a few cars, depend on pressure, while the most popular and generally applied forms 1916 model cars depend on electricity as a source of power fo small electric starting motor. Electric starting and lighting s tems have been made in many forms, though the basic princip of operation are practically the same in all systems that can grouped in several main classifications. It will not be possil to describe all in a general treatise of this nature, but if t features of the leading systems are outlined it will not be diffic for the repairman to became familiar with the principle of oth systems which may be slightly different only in points of min detail. Before discussing the electrical starting means, it will necessary to give brief consideration to the mechanical and pne matic starting systems which have received some degree of pr tical application and which are still advertised in trade prints.

Mechanical Starters.—While different makes of cars h:
marketed using air starting systems, there has been no ca
with a mechanical starter, so wherever these are used th

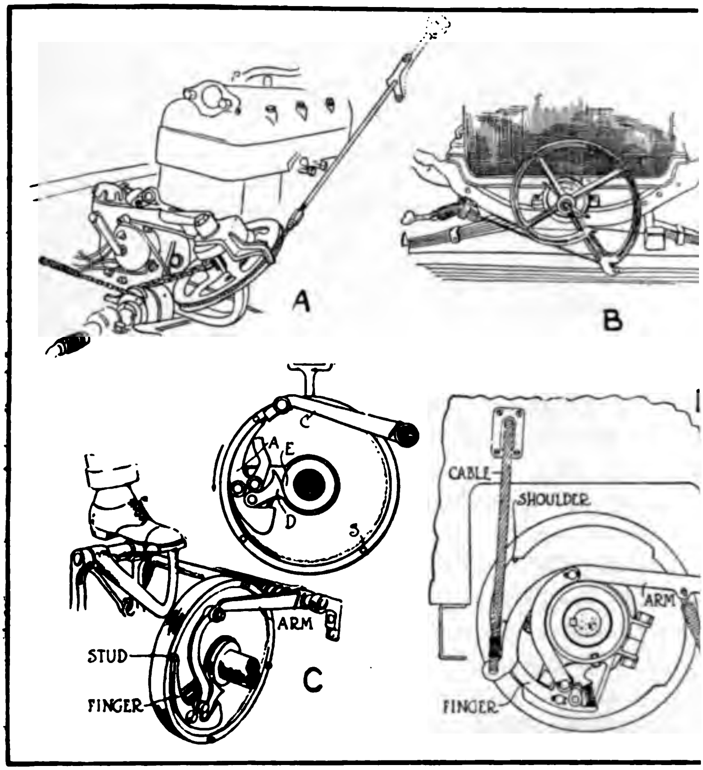


Fig. 281.—Showing Construction of Mechanical Devices for S Gasoline Engine from the Operator's Seat.

been applied by the owner of the vehicle and not the manuf
Owing to the wide distribution of the Ford automobile,
fact that the makers make no provision for a self-starting
various forms of simple starters by which the motor
cranked from the seat have been offered. Two of these ar
at the top of Fig. 281. That at A consists of a ratche

which is attached to the starting end of the crankshaft and whic is operated by means of chain connection with the smaller pulle of a two diameter pulley wheel. The larger wheel carries a wi cable which is attached to a straight rod running through th dashboard and terminating in a handle convenient to the drive hand. A pull on the spade type handle provided at the end o the rod will move the pulley wheel and produce a correspondin movement of the starting ratchet which turns the engine cranksha over in the same way as the hand crank does. A modification o the device shown at A is outlined at B. This works on the sam principle, except that an odd-shaped member is used to turn ove the engine crankshaft. These devices are in no sense of the wor "self-starters," but on light motor cars they provide an effectiv substitute in that the engine may be turned over without undu exertion and without leaving the seat. This is an advantage c some moment when the engine stalls in traffic, or under conditior where it would be inconvenient to get out of the car.

Two types of mechanical starters known as the Wilkinson ar shown at the bottom of the illustration, Fig. 281. The one at I is operated by pulling a handle on the dash, the one at C by a peda designed for foot actuation. The mechanism is such that th flywheel is pushed around by a lever which will engage with eithe a stud or a shoulder on the flywheel. The type at the left use the studded flywheel, there being four of these marked "S." When the arm C is moved by depressing a pedal, the finger A contacts with one of the studs and turns the flywheel. Retur engagement is produced by the large spring shown. In order t minimize liability of injury from backfire, the Wilkinson devic is constructed so that the pawl D rises on the cam which bear against the collar E, and thus throws the finger out of engage ment with the stud. One thrust of the pedal will turn the fly wheel of a four-cylinder engine sufficiently to cause one cylinde to fire should ignition and carburetion and carburetion system be functioning properly. The type at D is just as simple, but i modified somewhat in its construction. In this a hand lever i used to rotate the flywheel, and instead of using studs on th flywheel rim, four shoulders in the interior periphery do the work

These shoulders may be cast with the wheel, or in some cars it is possible to have them cut in the flywheel. The operation is the same as that of the type previously described as the movement of the cable causes the finger to engage with one of the shoulders, and thus turn the flywheel.

The results obtained with any of these mechanical starters are not to be compared with that obtained from an electrical device which spins the motor much faster than normal hand-cranking speed, whereas the mechanical starter produces a movement of not more than half a revolution of the flywheel. Various forms of spring-operated starters have been devised and placed on the market, but these have not been very popular on account of their bulk and lack of reliability. The amount of power that can be stored in a spring is not great, and at the most the motor could only be turned over three or four revolutions. If the ignition or carburetion systems were not functioning just as they should be, it will be apparent that the spring would be unwound and incapable of starting the motor. In order to turn the motor over it is necessary with most of these starters to rewind the spring with a hand crank provided for the purpose. If the engine starts promptly the spring is rewound automatically by the engine, and as long as the engine starts without delay the starter is available for use. Practically all of these devices require special fittings, with the exception of those described for the Ford car, and as full instructions are furnished by their makers for application the repairman who is called upon to fit a mechanical starter may do so without trouble by following the instructions provided.

Pneumatic Starters.—Three prominent makes of automobiles which have been marketed in fairly large numbers, namely the Winton, Pierce-Arrow and Chalmers, have used pneumatic or air starters all of which have operated on exactly the same system. At the present time these cars are furnished with electrical starters of the conventional pattern. In case the repairman is called upon to repair one of the models equipped with an air starter, the writer believes it necessary to consider the arrangement of the parts and the method of operation briefly before considering the subject of electrical starters. All the components of typical sys-

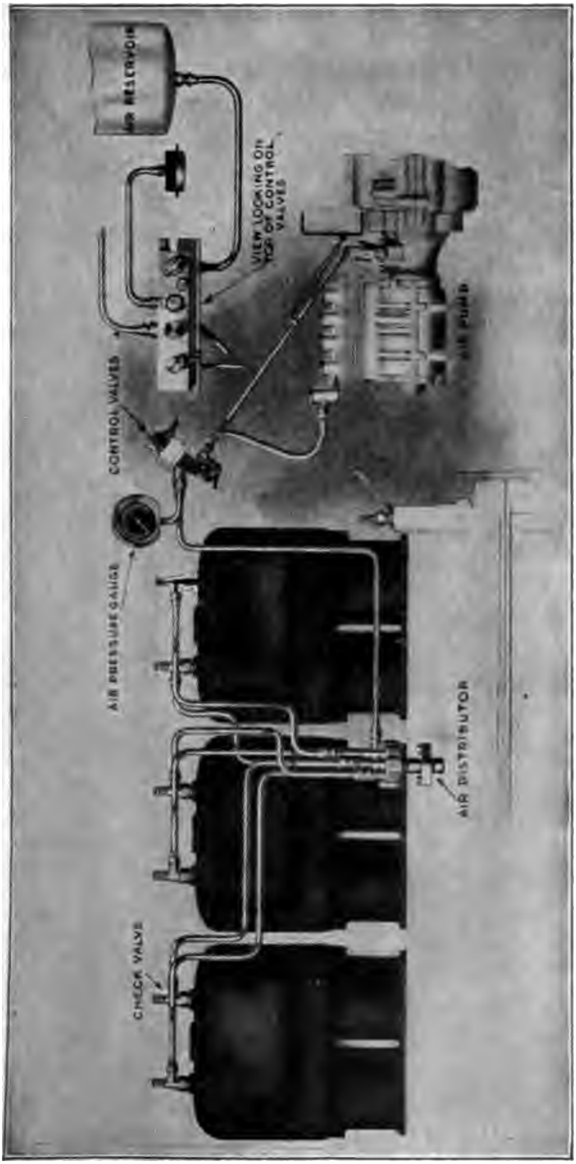


Fig. 282.—Diagram Showing Parts of Air Starting Systems Used on Some Early Models of Pierce-Arrow Automobiles.

tems, one of which was used on Pierce-Arrow cars, is sho Fig. 282. It will be observed that an air pump of the four-der type was attached to the gear box and driven from the co shaft of that member. This supplied air to an air reserv container attached to the chassis. This container communi with the top of an air distributor when a suitable control was open. An air pressure gauge is provided to enable o ascertain the air pressure available. The top of each cylin provided with a check valve, through which air can flow or one direction, i.e., from the tank to the interior of the cyli Under explosive pressure these check valves close. The functi

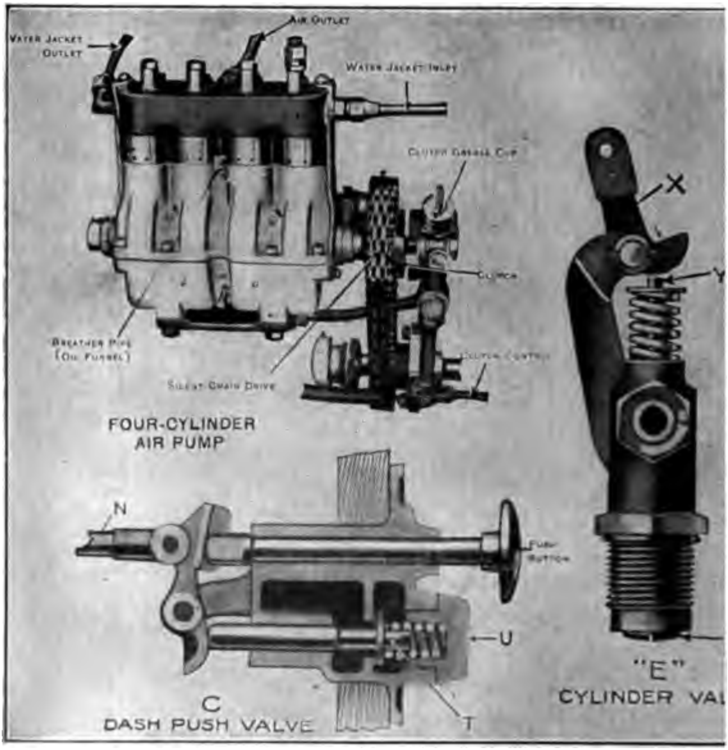


Fig. 283.—Some Important Components of Early Chalmers Air Sta System.

tributor is practically the same as that of an ignition timer, rpose being to distribute the air to the cylinders of the only in the proper firing order. All the while that the is running and the car is in motion the air pump is func- ; unless thrown out of action by an easily manipulated control lever. When it is desired to start the car a starting is opened which permits the air to flow to the top of the utor, and then through a pipe to the check valve on top cylinder about to explode. As the air is going through considerable pressure it will move the piston down just as plosion would, and start the engine rotating. The inside of tributor rotates and directs a charge of air to the cylinder) fire. In this way the engine is given a number of revo- , and finally a charge of gas will be ignited and the engine ff on its cycle of operation. One of the advantages of the rter system is that a source of air is provided for blowing s.

general arrangement of the Chalmers air starter was prac- the same as that depicted. Some of the components were erent construction. Instead of being driven by enclosed ; the air pump was operated through a silent chain from mp shaft, as shown in the upper left hand corner, Fig. 283. air pump the cylinders were water jacketed in order to t overheating. The construction of the dash push valve is shown at C. This member not only serves to admit air center of the distributor, but also opens the cylinder start- ves to permit the air to flow into the cylinder. The start- ve construction is clearly shown at E, this consisting of a fitting adapted to be screwed into the cylinders and com- ting with the interior of the combustion chamber. The bell X was used to depress the valve stem Y, and thus provide nication between the air distributor and the combustion r interior. As the distributor was one of the important of all air-starting systems, that used on the Chalmers car quipped with the air starter is shown at Fig. 284. By re- to the sectional view at the right of the illustration it will arent that its function is practically the same as that of a

primary timer or secondary distributor of a magneto, except tl instead of distributing electrical energy a blast of air was direc to the cylinders in the proper firing order. The rotating distribu disc is provided with one slot which registers consecutively w the openings to which the pipes running to the various cylind were fastened. About the only trouble with an air-starting s tem was faulty check valve action or leaks in the pipe line distributor which permitted the escape of air. If no air press was supplied to the tank the pump was at fault. This may easily determined on inspection; the same troubles should be look for as described for the air pressure pump sometimes used in co nection with the pressure system of fuel supply.

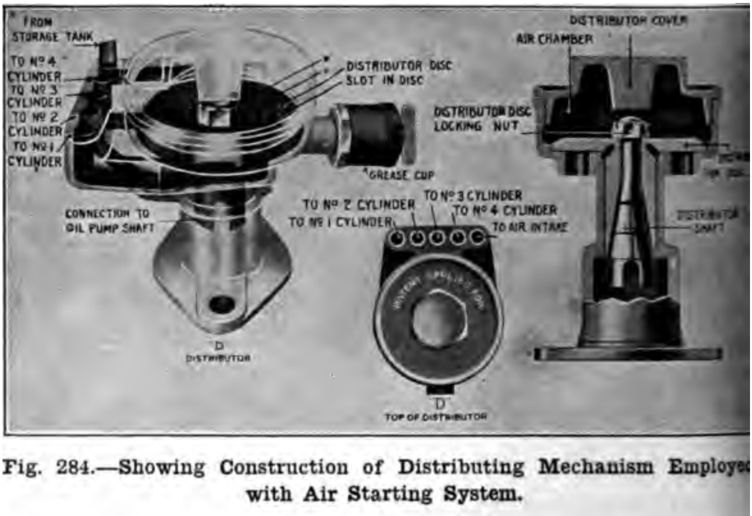


Fig. 284.—Showing Construction of Distributing Mechanism Employe with Air Starting System.

Pres-to-lite Primer.—Where a car is equipped with a Pr to-lite gas tank it is possible to secure easy starting by hand cran ing, and even to run the engine on acetylene gas in an emergen if the gasoline supply fails by using a simple priming fitting sho at Fig. 285. The outfit consists of an automatic reducing va attached to the gas tank, a pipe line running to the dash, and *push* valve so mounted that acetylene gas may be admitted i

e inlet manifold through a pipe running from the push valve the intake member. As shown at A, a simple lever is rigged up the push button may be operated from the front of the car. t B the push button is worked by the foot. The arrangement of ie parts is clearly shown in the view at the bottom of the illus-ation. It is said that a properly charged gas tank will run a 5 H. P. motor from ten to twelve miles if the gasoline supply iould fail. The reason the acetylene gas provides easy starting is iat it is very inflammable and does not need to be vaporized as ie liquid fuel does. The gas primer is of special value when sed in connection with mechanical starters of various kinds. Be-ore depressing the push button it is necessary to open the main hut-off valve incorporated with the push button assembly on the ash. This permits the gas to flow from the automatic pressure egulator to the body of the device where the push button valve rovides access with the pipe running to the intake manifold.)bviously this priming system can be used only with cars equipped rith a gas tank. On the modern electrically lighted and started ars the gas tank will be unnecessary, and is not apt to be used. Iowever, the gas tank would probably be applied for lighting urposes on cars equipped with air starters, and on these models t would be of particular advantage inasmuch as the tendency f the air current passing to the cylinders is to retard prompt aporization of the fuel sucked in from the carburetor, the rich cetylene gas would provide a rich mixture, and would enable the ngine to run for a long enough period to permit the explosion to heat up the cylinders enough so the gasoline would vaporize promptly.

Electric Starter Forms.—Electric lighting, cranking and ignition systems for motor cars are of such recent development that it is not possible to describe all systems used for this purpose. Not only do the individual systems vary in detail, but the components of the same system are often of different construction when used on cars of different makes. The standard equipment must include three component parts, namely, the generator which is driven by the engine and which produces electric current to keep the storage battery charged, and the starting motor which is in

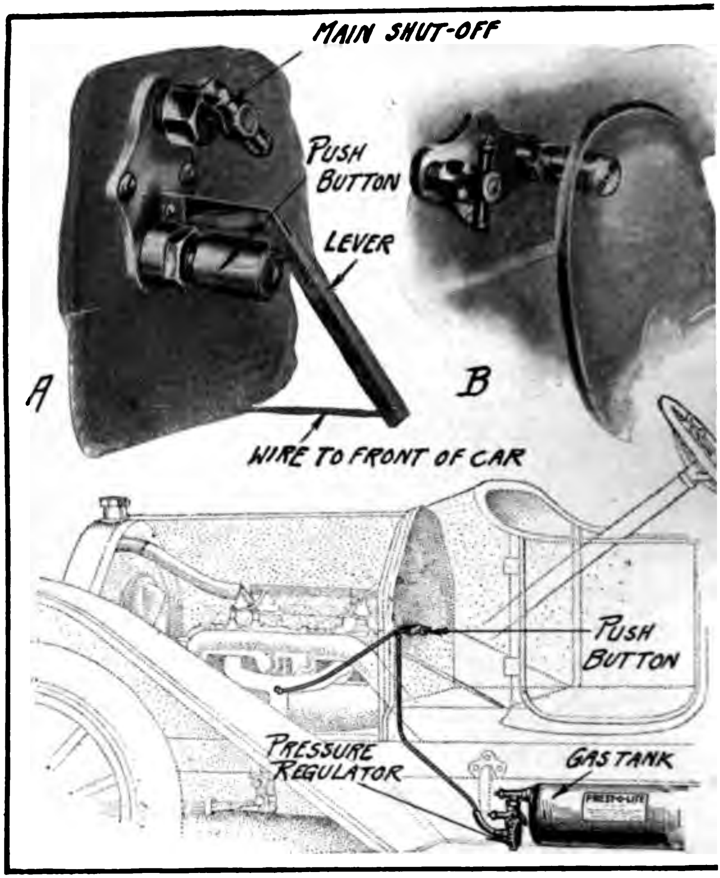
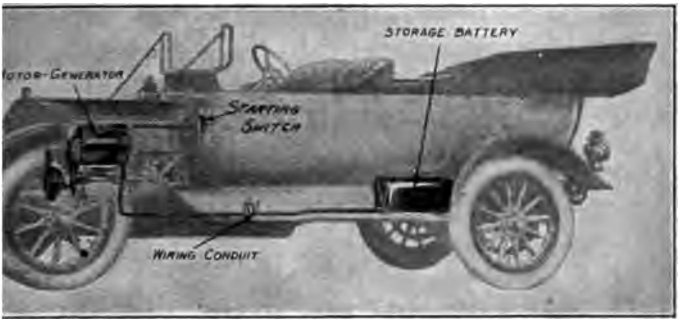


Fig. 285.—Showing Method of Utilizing Pres-to-lite Gas Tank to l tate Starting the Automobile Power Plant.

mechanical connection with the engine and in electrical c tion with the storage battery when it is desired to turn the over for starting. If the motor and generator are combi one instrument the starting system is known as a one unit If the motor is one appliance and the generator another, tl tem is said to be a two unit system. Each of these has adva and both forms have demonstrated that they are thoroughly

addition to the three main items enumerated, various s such as switches, ammeters, connectors, wiring, pro- rcuit breakers, automatic current regulators, etc., are for the convenient distribution and control of the elec- nt. The arrangement of the parts of a typical one unit which the motor-generator is used only for starting and s shown at Fig. 286. This shows the location of the



—Side View of Typical Automobile Showing Application of Entz One Unit Starting and Lighting System.

arts in their relation to the other components of the :. The motor generator is mounted at the side of the ıd is driven by the magneto drive shaft when used as a , and serves to drive the engine through this means when as a motor. The ignition current is supplied from in- t source, a high tension magneto. The starting switch controlling the lighting system are placed on the dash, storage battery is carried under the floor of the tonneau. ɜm, which is known as the Entz, will be described more in proper sequence.

ements of a one unit system are shown in diagram form t of Fig. 287. It will be observed that the armature car- ːommutators, one of which is used when the armature is r the engine and when the device serves as a current , the other being employed when the operating conditions ɪed and the electrical machine is acting as a motor to turn

over the engine crankshaft. When the device is driven as a g erator the small sliding pinion on the short end of the shaft out of engagement with the spur gear cut on the flywheel terior. When it is desired to start the engine the spur gear meshed with the member cut on the flywheel and the curr from the storage battery is directed to the windings of the elect machine which becomes a motor and which turns over the eng crankshaft. When the device is working as a generator the c rent that is developed goes to the storage battery, and from t member to the various current consuming units.

Sometimes the motor and generator are combined in one casi and the system so provided is erroneously called a "one uni

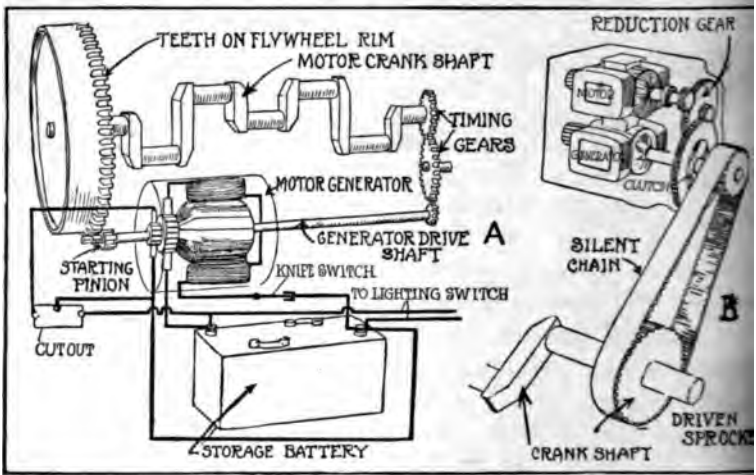
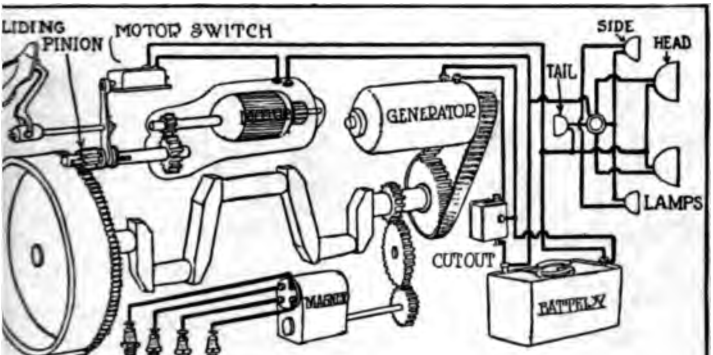


Fig. 287.—Diagram Defining Application of One and Two Unit Mot Starting Systems.

system. This construction is shown at the right of Fig. 287. reality such a system is a two unit system, because the electri machines are uni-functional instead of performing a dual funct as does the combined-motor-generator at the right of the ill tration. The wiring is shown in simplified form and should easily followed by any repairman. The parts of a two unit st

1 lighting system are shown at Fig. 288. This system is nes called a "three unit" system, on account of having a of independent current supply for ignition purposes. As observed, the generator is driven from the motor crank- y silent chain connections, one of the terminals passing ı the cut-out device and to the storage battery, the other ıl running directly to the storage battery terminal having by-pass or shunt wire attached to the cut-out. All the time e engine is running the generator is delivering electricity storage battery.

vill be observed that the storage battery is also coupled to hting circuits which are shown in a group at the right of



88.—Diagram Showing Components of Three Unit Starting, Lighting and Ignition Systems.

ıstration, and to the electric starting motor as indicated. the storage battery terminals is joined directly to the switch ıl by a suitable conductor, the other goes to one of the ıls on the starting motor, while the remaining terminal of rting motor goes to the switch. In this system, when the liding pinion is meshed with the flywheel gear, the switch wn on simultaneously, and the current that flows from the battery through the windings of the starting motor rotates

the engine crankshaft by means of reduction gears shown. as the engine starts the foot is released and a spring : switch out of contact, and also disengages the sliding pin the flywheel gear.

The actual appearance of a motor fitted with a two ur starting and lighting system is shown at Fig. 289. It

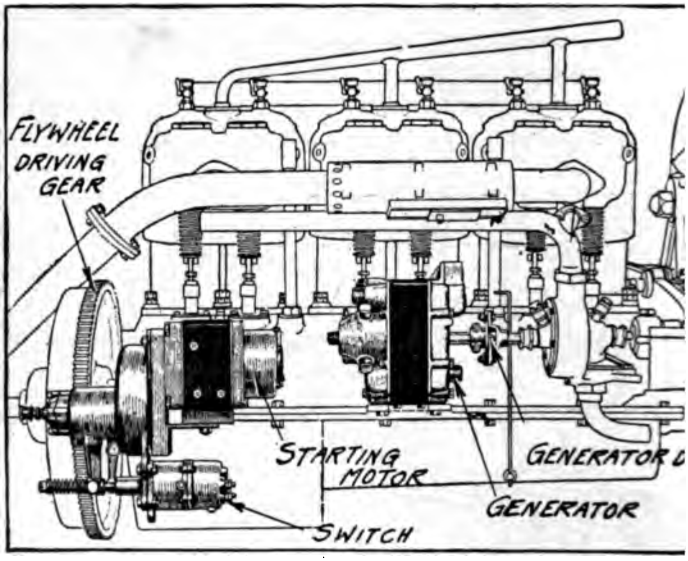


Fig. 289.—Method of Attaching Starting Motor and Generator o Three Unit System on Six Cylinder Engine.

observed that the generator is driven from the pumpsha sion by a leather universal joint, while the starting motor is at the back end of the crankshaft in such a position concealed sliding pinion may be brought into engagement flywheel driving gear. The interlock between the startir and the pinion shifting means is also clearly shown.] starting systems may be operated on either six- or tv current, the former being generally favored because th *lamps* use heavier filaments than those of high voltage,

t so likely to break due to vibration. It is also easier to install six-volt battery, as this is the standard voltage that has been ed for many years for ignition and electric lighting purposes fore the starting motors were applied.

In referring to a system as a one unit system of lighting, arting and ignition, one means that all of these functions are corporated in one device, as in the Delco system described in the hapter on ignition. If one unit is used for generating the lighting and starting current, and also is reversible to act as a motor, ut a separate ignition means is provided such as a high tension nagneto, the system is called a "two unit" system. The same lesignation applies to a system when the current generating and gnition functions are performed by one appliance, and where a eparate starting motor is used. The three unit system is that in which a magneto is employed for ignition, a generator for supplying the lighting and starting current, and a motor for turning over the engine crankshaft. Before describing the individual systems it would be well to review briefly the various components common to all systems.

The generator, as is apparent from its name, is utilized for producing current. This is usually a miniature dynamo patterned largely after those that have received wide application for generating current for electric lighting of our homes and factories. The generators of the different systems vary in construction. Some have a permanent magnetic field, while others have an excited field. In the former case permanent horseshoe magnets are used as in magneto. In the other construction the field magnets, as well s the armature, are wound with coils of wire. In all cases the lynamo or generator should be mechanically driven from the ngine crankshaft either by means of a direct drive, by silent hain, or through the medium of the timing or magneto operating ears. Belts are apt to slip and are not reliable.

All the current produced by the generator and not utilized by he various current consuming units such as the lamps, ignition ystem, electric horn, etc., is accumulated or stored in the storage attery, and kept in reserve for starting or lighting when the ngine is not running or for lighting and ignition when the car

is being run at such low speed that the generator is not suppl
current. Storage batteries used in starting systems must b
special design in order to stand the high discharge and to perf
efficiently under the severe vibration and operating condition
cidental to automobile service. The storage battery may be
stalled on the running board of the automobile, under the b
or under the front or rear seat, the location depending upon
design of the car and the degree of accessibility desired.
best practice is to set the storage battery in a substantial carr
case held by rigid braces attached to the frame side and c
members. If the battery should be set under the tonneau f
boards, a door must be provided in these to give ready acce
the battery.

The starting motor, which takes the place of the common h
crank, is operated by current from the storage battery, and
high speed armature rotation is reduced to the proper cran
speed by reduction gears of the different forms to be describe
proper sequence. The construction of the starting motor is p
tically the same as that of the dynamo, and it operates on the s
principle, except that one instrument is a reversal of the othe

In order to secure automatic operation of a lighting and st
ing system several mechanical and electrical controls are nec
these including the circuit breaker, the governor, which may
either mechanical or electrical, and the operating switches.
circuit breaker is a device to retain current in the storage bat
under such conditions that the battery current is stronger than
delivered from the generator. If no circuit breaker was provi
the storage battery could discharge back through the gener
winding. The circuit breaker is sometimes called a "cuto
The circuit breaker is usually operated by an electro magnet,
may be located either on the generator itself or any other
venient place on the car, though in many cases the circuit bre
are usually mounted on the back of the dashboard. This de
is absolutely automatic in action and requires but little attenti

The governors are intended to prevent an excessive outp
current from the generator when the engine runs at extr
high speed. Two types are used: one mechanical, operat

ı force, and the other electrical. The former is usually drive mechanism mounted on the generator shaft which .lly limits the speed of the dynamo armature to a defitermined number of revolutions per minute. The maxient output is thus held to the required amount indeof the speed at which the car is being driven. The device minimizes the possibility of overheating the genrcharging the battery at high car speeds. The electrical governing does not affect the speed of the armature, but ıe output of the generator by means of armature reacı reversed series field winding. The governors usually maximum generator output of from ten to twelve amıgh the normal charging current is less than this figure. ctically all systems an amperemeter is mounted on the ıat it can be readily inspected by the driver, this indiall times the amount of current being produced by the r drawn from the battery. If the indicating needle of emeter points to the left of the zero point on the scale, that the battery is furnishing current to the lights or ·ent consuming units or discharging. When the needle the other side of the scale, it means that the generator ng current to the battery which is charging it, the amount or discharge at any time can be read from the scale on f the amperemeter. Some of these instruments have the harge" and "discharge" under the scale in order to ; operator to read the instrument correctly.

ər important element is the lighting switch, which is ıounted at some point within convenient reach of the ·. This is often placed on an instrument board on the ıe cowl in connection with other registering instruments. rily constructed, the switches are made up of a number ınd the wiring is such that the head, side and tail lamps ontrolled independently of each other. For simplicity ənience of installation, the switch is usually arranged l circuits are wired to parallel connecting members or ' placed at the rear of the switch. In some cars, as the 80 model, the switch units are placed on the steering

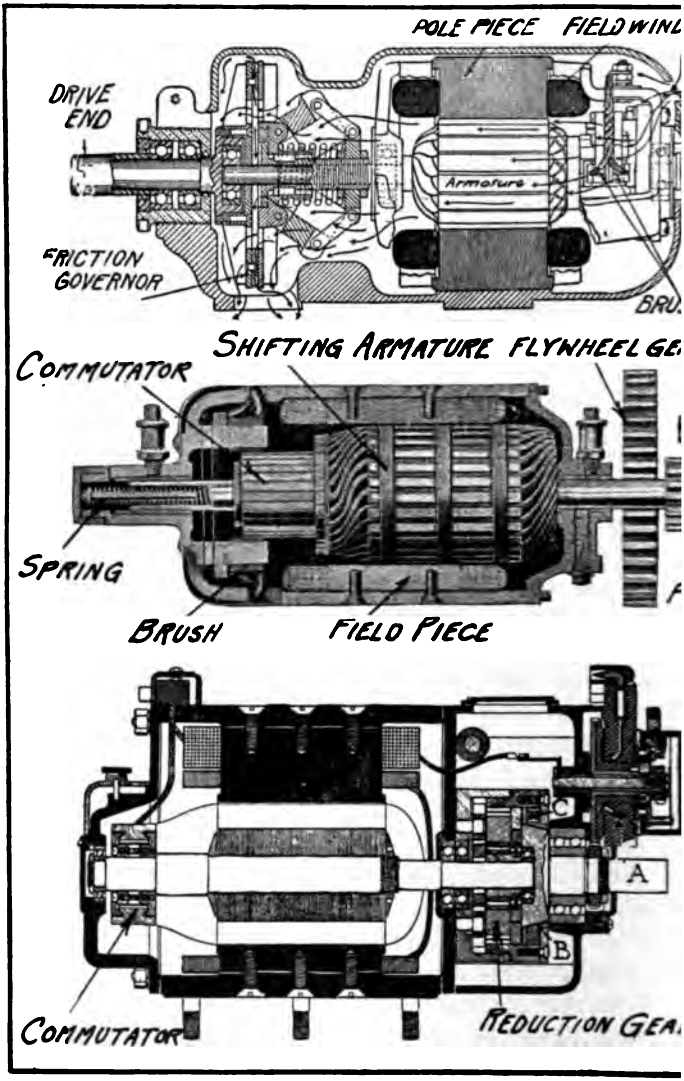


Fig. 290.—Showing Construction of Typical Generators and Motors.

n. As but little current passes through the lighting switch ›ntacts are not heavy in construction as are those of the ıg switch.

e function of the starting switch is to permit the current to 'rom the storage battery to the starting motor, when it is ary to start the car. It is arranged usually so as to be r operated by the foot and is nearly always installed at convenient position on the toe board of the car. As we previously shown, the starting switch is often interlocked he starting motor gearing so that the operation of engaging ar with the flywheel and of turning on the current to the ıg motor are accomplished simultaneously. The lighting and starting wiring systems are independent of each other, and ›e easily found as that used to convey the high amperage ıg current is of heavy round single conductor cable, while ghting wiring is usually a light multiple strand cable. In to prevent chafing and depreciation of the insulation the ; is often protected by conduits of a flexible metal tubing, ıe terminals are extremely heavy and well adapted to resist ɔration which is unavoidable in automobiles.

nerators and Starting Motors.—Essentially there is not difference in construction between a starting motor and a tor as the principles upon which they operate are prac- the same. A machine that is capable of delivering current direction when driven by mechanical power will produce nical energy if electrical current is passed through the wind- a reverse direction. The construction of typical starting and generators may be readily understood if one refers illustrations at Fig. 290. That at A is one form of the k Davis governed dynamo, which is of the limited armature type. The power is directed to the driving member of a n clutch which turns the generator armature by means of n contact with a disc attached to but slidably mounted on nature shaft. This plate is held in contact by a coil spring. ' of hinged governor arms are attached to the driven clutch while the other ends are attached to a rotating spider mem- stened on the dynamo armature shaft. When the speed in-

creases beyond a given point the governor weights fly out centrifugal force, and reduce the amount of frictional between the clutch members in proportion as the armatu

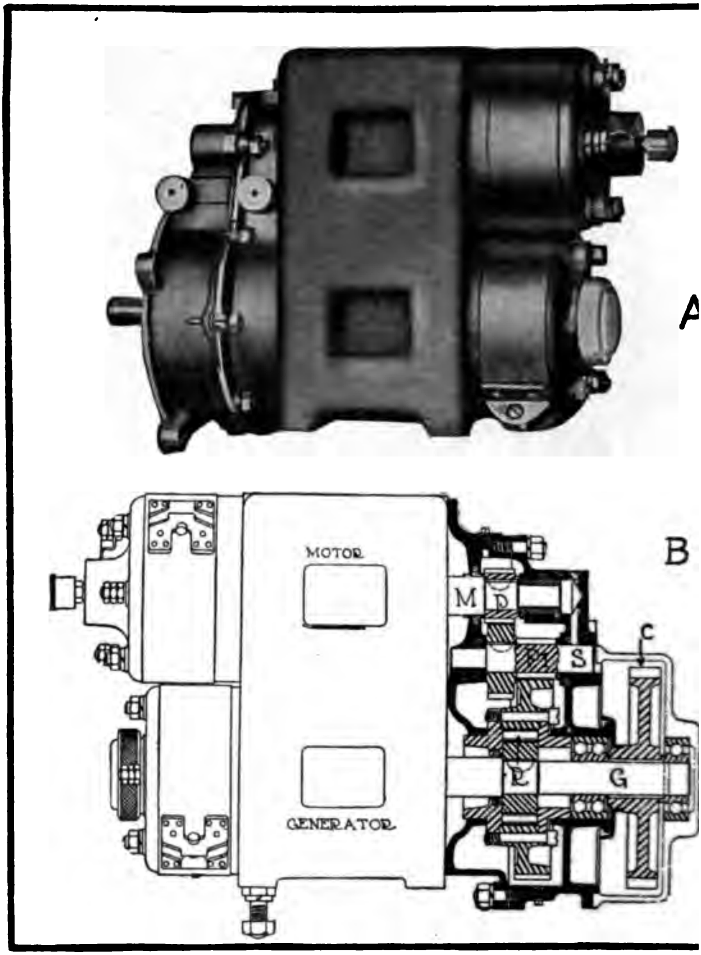


Fig. 291.—The Disco Two Unit Outfit Having Motor and G Mounted in Common Carrying Case, the Motor Being Place the Generator.

ed augments, until the point is reached where there is no ctional contact between the parts of the clutch and the driving te is turning at engine speed, while the driven member that parts motion to the armature is gradually slowing down and mitting the tension of the coil spring to overcome that force duced by rapid rotation, and to bring the discs in contact again just a sufficient length of time to enable the armature to intain its rated speed even if the engine is running faster than mal.

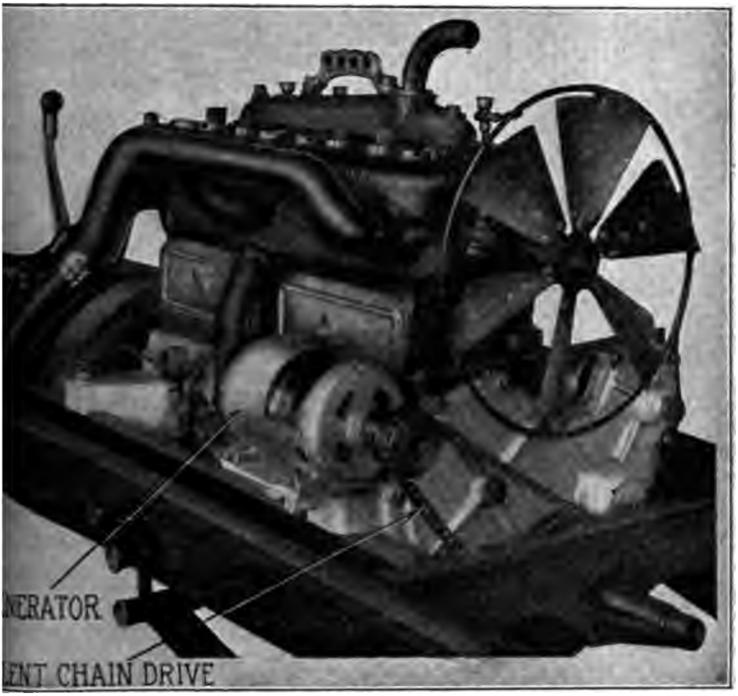
A typical starting motor, which is of the Rushmore design, hown at B. As will be evident, this is practically the same in struction as the generator shown above it, as far as essentials concerned, except that no governor is provided and the arma- shaft is fitted with a small spur pinion designed to engage the spur gear on the engine flywheel. No mechanical inter- nection is necessary between the drive pinion and the elec- l starting switch. As soon as the current flows through the ature of the motor it will move that member laterally and matically engage the pinion of the flywheel gear. As soon starting switch is released, a coil spring will push the start- motor armature back again in the position shown in the illus- ion, and thus automatically bring the pinion out of mesh with flywheel gear. In order to obtain a sliding feature this motor ture shaft is mounted on plain bearings instead of ball bear- which are standard equipment on practically all machines of nature.

The device outlined at Fig. 290, C, shows the construction fol- d when the ignition function is combined with a current gen- r and starting device having the three functions performed ne instrument. The general construction is the same as in device previously outlined. The drive shaft of the device is ted to be attached to the engine by direct mechanical means. n the device is used as a current generator, the armature is n by the shaft, whereas if the device is used as a motor the ture drives the shaft A through a planetary reduction gearing ller clutch. Regardless of whether the device is used as a r or generator, the distributor for ignition purposes is driven

in the same direction, and at the proper speed to insure igni as it is driven directly from shaft A, which turns at crank speed.

An example of a double deck combined instrument in which generator is carried in the lower portion of the casing and starting motor at the upper part is clearly shown at Fig. 291. view at A shows the external appearance while the partial sec at B makes clear the arrangement of the reduction gearing roller clutch. This type is meeting with favor because it mounted easily, and also on account of the simple mechanical nection to the engine. While the two units are electrically rate, i.e., each having its own field and armature, it may be sidered as one unit mechanically. The double deck instrum shown is designed for application to the side of a gasoline connecting by chain or gearing to the pump or magneto shaft. It should be noted that this chain or gear is the nection between the machine and the engine, and that it not only for transmitting the engine energy to the gener also acts to transmit the power from the starting motor the engine crankshaft when it is desired to start the pow It will be apparent that in a combined instrument of that it is necessary to have a fairly low gear ratio betw motor and the engine in order to reduce the high speed motor armature rotation to a speed low enough to turn the engine crankshaft. At the other hand, once the power is started the generator armature must turn at a slower than that of a starting motor, and if it is run from the shaft or magneto drive shaft it will turn fast enough to ate the proper quantity of electricity. The starting motor, ever, must be geared down in order that it may exert the ing torque through the high leverage furnished by the redu gear. The motor occupies the upper position as shown Fig. 291, and carries a pinion P keyed to the end of its arm shaft M. This pinion transmits the drive to an intermediate S, which in turn drives the large gear forming the outer cas an overrunning roller clutch R. The inner or driven m of this clutch is mounted rigidly on the armature shaft G

ator and carries the drive through to the outer chain gear C cranking the engine. As soon as the engine explodes and the runs above that represented by the starting motor at the clutch the latter comes automatically out of action, thus per-ng the generator to obtain its power in the normal way through



292.—Method of Driving Gray & Davis Generator by Silent Chain from Engine Crankshaft.

hain wheel C attached to the dynamo shaft G. The motor ture above comes to rest as soon as the starting switch is re-. The generator of this device has its output controlled by bination of armature reactions and a bucking coil, while the y is protected from discharging back through the generator imple magnetic contact *breaker or* cut-out.

Generator Driving Methods.—When electric lighti applied to automobiles it was not considered necessary generators by positive connection, and the early devic nished with pulleys for flat or V belt drive. At the pr

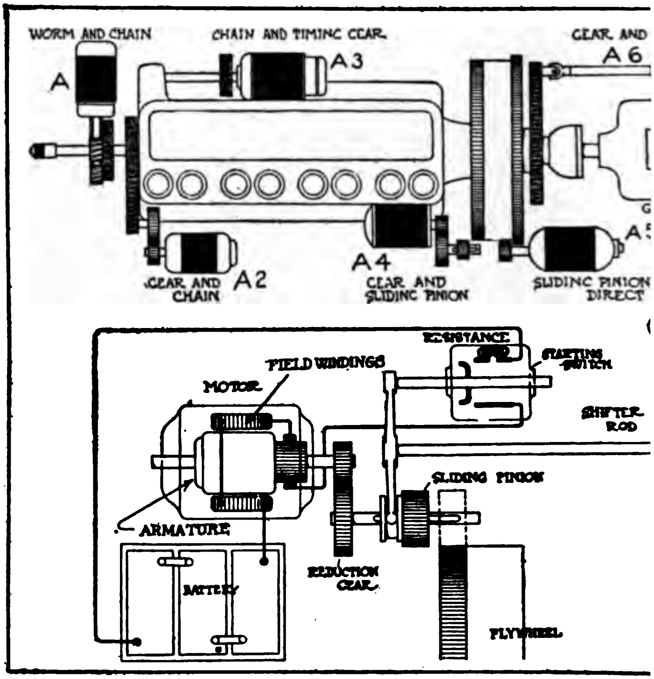


Fig. 293.—Diagram Showing Methods of Transmitting Power Motor to Power Plant, Also Simplified Diagram Showi nected Starting Switch and Motor Starting Gear.

is considered highly important to provide a positive connection that will not slip between the generator anc crankshaft. The common systems where the generato rate unit from the starting motor and in those form: starting and generating functions are combined, invol tion with the motor crankshaft through some form of g *will be* apparent in Fig. 289, the generator is driven l

niversal joint connections with an extension of the pump shaft. 'he motor crankshaft imparts its power through the camshaft timng gear to the small pinion utilized in driving the water pump. n the generator application shown at Fig. 292 the armature is roated by silent chain connection with a gear on the motor crankhaft. There is not the diversity of drives for the generator as here is in the methods of connecting the starting motor to the nd of the crankshaft.

Starting Gearing and Clutches.—In order to show the variety of driving means used in connecting the starting motor to the work of turning over the engine crankshaft, the leading systems have been grouped in one illustration at the top of Fig. 293. Starting from the front of the motor, the first method shown is by means of a worm gear initial or primary reduction and chain connection from the worm-driven shaft to the motor crankshaft. In some cars the worm reduction is used having the starting motor mounted at the side of the change speed gear box instead of attached to the motor crankshaft. The reduction in speed may be by means of the spur gears and chain, as shown at A-2, or by a chain to a shaft connected with the timing gear, as in A-3. The method at A-4 is a very popular one, including a reduction to an intermediate shaft, which carries a sliding pinion designed to engage the gear on the flywheel rim. The method at A-5 is used with the Rushmore starter, the pinion being brought into direct engagement with the gear on the flywheel by the axial movement of the armature when the current is supplied to the field winding. The method at A-6 permits of attaching the starting motor securely to the frame side member at a point near the gear box, where it will be out of the way and not interfere with the accessibility of the power plant. When mounted in this manner the drive is by a double universally jointed shaft to a small silent chain sprocket, which connects to a much larger member attached to the engine flywheel or crankshaft.

The complete system shown at Fig. 293, B, is the most popular of all that have been used. This shows the application of the starting motor, outlined at A-4. The mechanical interlock between the sliding pinion on the intermediate shaft and the starting switch s clearly shown. Before the pinion engages the gear on the fly-

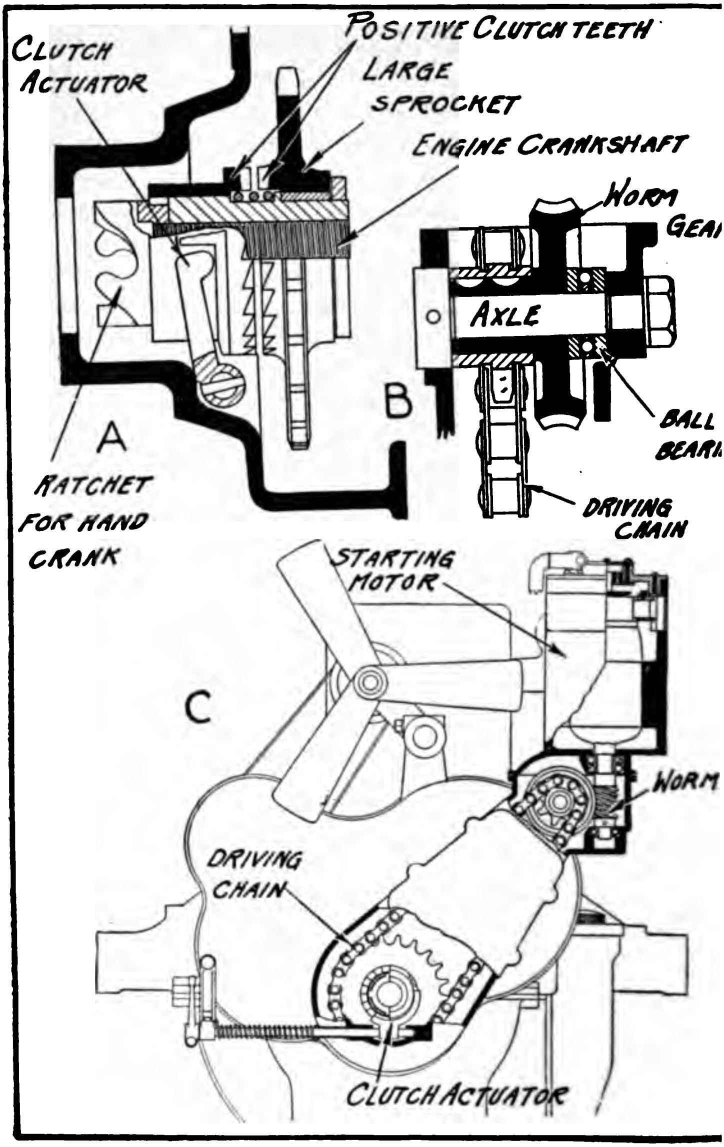


Fig. 294.—Method of Mounting Starting Motor Having Speed Redu
Through Worm Gears and Roller Chains.

wheel rim the switch makes contact, but owing to the resistance terposed in circuit the motor will turn slowly to permit of m ready engagement of the sliding pinion. As soon as the pinioı fully engaged with the large gear the resistance is cut out and motor draws what current it needs from the storage battery, t being enough to produce the torque necessary to turn over the gine flywheel and the crankshaft to which it is attached at sı speed as will produce prompt starting.

The actual application of the system, shown at A-1, Fig. 293 outlined at C, Fig. 294. It will be observed that the starting ı tor is attached to the side of the engine in a vertical position that it drives the intermediate shaft by means of a worm on motor armature, which engages with a worm gear on the inter: diate shaft, which also carries the driving sprocket, as shown at A further reduction in speed is obtained owing to the differe in size of the small sprocket on the intermediate shaft and that tached to the clutching member normally revolving free on the ı tor crankshaft. It will be seen that the motor armature is s ported on ball bearings, and that one of these, backing the wo is a double row form capable of sustaining both the end thr and radial load imposed by the driving worm. In order to re the end thrust on the worm gearing successfully a ball thrust be ing is used, as shown at B. When it is desired to start the mc the clutch actuator, which is shown in the diagram at A, is pusl in until it engages the ratchet teeth cut on the face of the la sprocket. When the sprocket turns it must turn the engine cra shaft in the same direction, but just as soon as the engine r faster than the large sprocket the clutching action will be relea automatically by the ratchet teeth being thrown out of enga ment. If it is necessary to start the engine by means of a ha crank this may be done by inserting the starting crank in the sta ing ratchet provided on the extreme end of the crankshaft. ' large sprocket is normally free and the engine crankshaft tu without producing a corresponding movement of the sprocket me ber. The general arrangement of the parts is so clearly shc that no further description will be necessary.

The construction of a typical overrunning clutch is clea

shown at Fig. 295. The electric starting motor is secur base on the crankcase of the gasoline engine and the moto is imparted through the medium of the small gear F carried armature shaft. This drives gear E, which turns at a lowe on account of being larger, and that in turn engages with which is still larger in diameter. The small pinion C, whic much slower than the motor pinion F, meshes with the lar

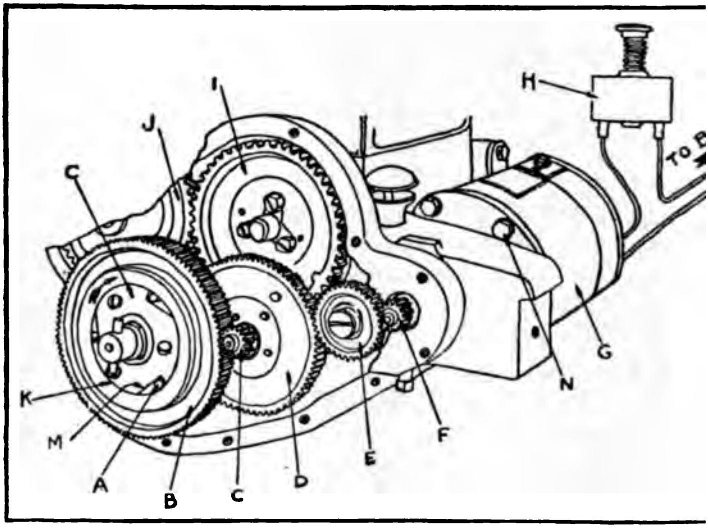
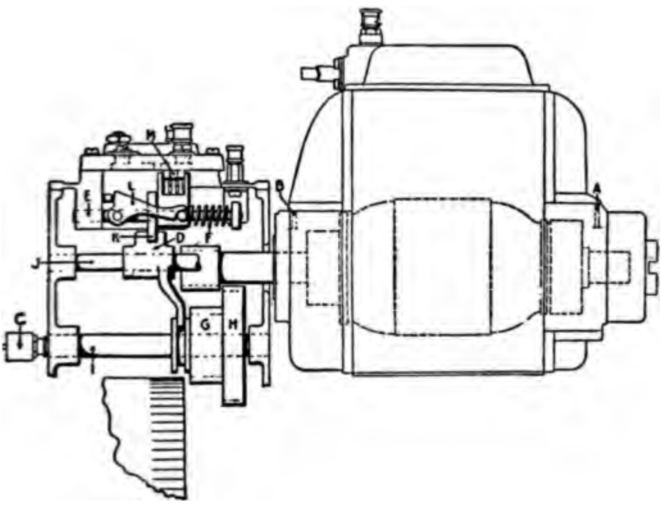


Fig. 295.—Defining Construction of Typical Roller Clutch.

B attached to the clutch body. The use of this gearing pro reduction of 40 to 1, which means that gear F must make 4 lutions to one of the clutch body.

The ratchet or driven member of the overrunning clut pinned to the engine crankshaft and revolves with it when tor is operating, rotating inside of the gear B, having a bea K and turning in the direction of the arrow. The membe three flat surfaces, M, cut at an angle to the inside of the On each of these a hardened steel roller, A, is held inside *gear by a* light spring and against the flat surface of the

e roller travels with the clutch and runs free against the the gear B when the engine is in motion and when the start-rs are idle. As soon as the current is directed to the elec-rting motor, the three rollers are bound between the clutch ıd the ratchet member carrying them and the crankshaft is until such time as the engine speed increases sufficiently to ı that of the member attached to the crankshaft.



6.—**Showing Interconnection between Starting Switch and Intermediate Pinion of Delco System.**

rrunning clutches are not necessary in those systems in he gears are moved into engagement, as in that shown at ;. In this the starting switch and the double shifting mem-H, are mechanically interconnected so that the starting vill not be completely engaged until gearing is in mesh. The 'ear H of the sliding members meshes with that on the arma-ıft, while the smaller of the pair, G, meshes with the fly-The arrangement of the parts outlined is used on the Cole

car. In the Hartford starting motor, which is shown at Fig the clutch is of the friction type and is engaged autom. when the energy is passed through the motor winding to ı movement of the engine crankshaft. The reduction betw·

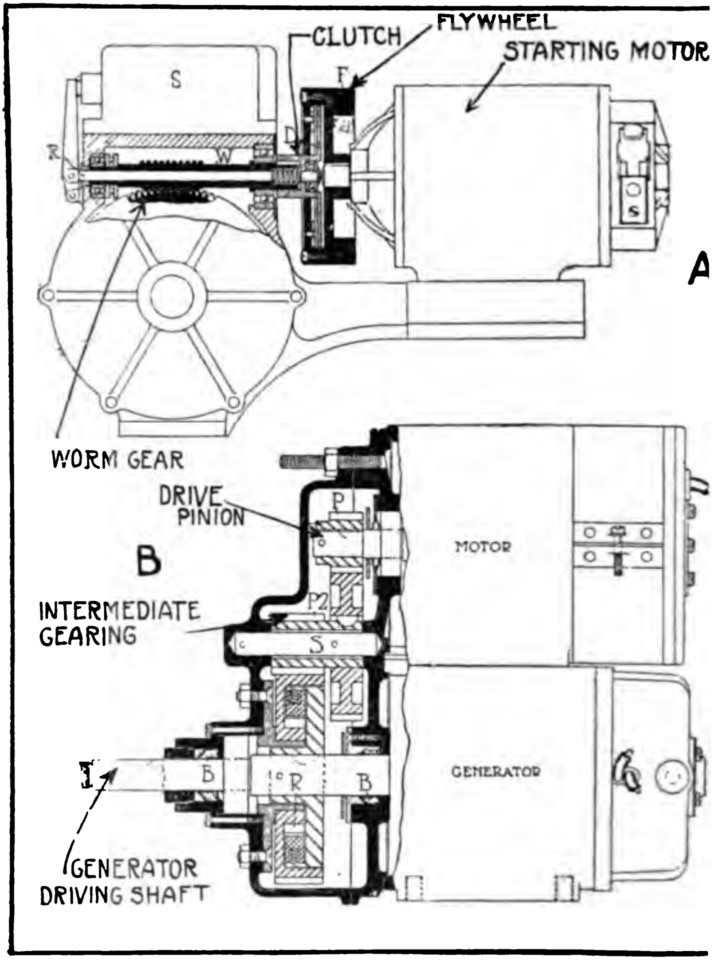


Fig. 297.—The Hartford Starting Motor Employing Worm Reduction at A, Ward-Leonard Combination at B.

starting motor and the crankshaft is made by a worm and worm gear. When the switch pedal is depressed and the switch blades go into contact the same movement produces pressure on the end of the lever attached to R R, which transmits a strong pull on the friction clutch and thus connects the motor to the starting gear. The Ward Leonard combination is shown at Fig. 297, B. In this the motor is carried above the generator, and but one driving gear is needed to operate both the generator and to enable the starting motor to turn over the engine crankshaft. The speed reduction is by an intermediate gear shaft, the general operation being the same as that of the Disco starter, previously described.

Switches and Current Controlling Devices.—The various methods of operating the starting switch, which may be interconnected with the gearing to turn the crankshaft, are shown at Fig. 299. All of the methods of actuating the electric self-starter may be grouped into three main classes: one, by hand lever; two, by pedals, and three, by semi-automatic means. The method at A is used on some Paige-Detroit cars, a hand lever, A, attached to the steering column being used to make the mechanical interconnection between the clutch pedal and the starting gear mechanism. In order to safeguard the gearing of the starter the electrical connection cannot be effected until this mechanical interconnection is made. After the hand lever is thrown over in the proper position, depressing the clutch pedal suffices to permit the electrical connection to be made and the gasoline engine started. In the Hupmobile control, which is shown at B, a small auxiliary lever S is used to put the starter into gear. The view at D shows a small pedal which is employed to make the starting connection. This is the most popular system, especially when pedal is connected with the current-controlling switch, so that the full amount of current will not flow to the motor until the reduction gearing is completely engaged.

An example of the semi-automatic method which is used on the cars employing the Entz starter, namely, the Franklin, Chalmers and White, is shown at C. To put the starter in operation it is only necessary to move the handle H on the dashboard or other convenient position, where it may be readily reached with the hand or foot. This method is called the semi-automatic, because

the starter operates all the time until the gasoline engine is by short circuiting the ignition. The first step is to throw dle to the ignition point, and after closing the ignition swi moved in the same direction until the storage battery has b nected to the starter generator. It is not necessary to tc handle again until one desires to stop the engine, as mo handle to the other extreme of its operating quadrant fir the connection between the storage battery and the motor g and then interrupts the ignition. With this starting systen motor should be stalled for any reason or slow down below

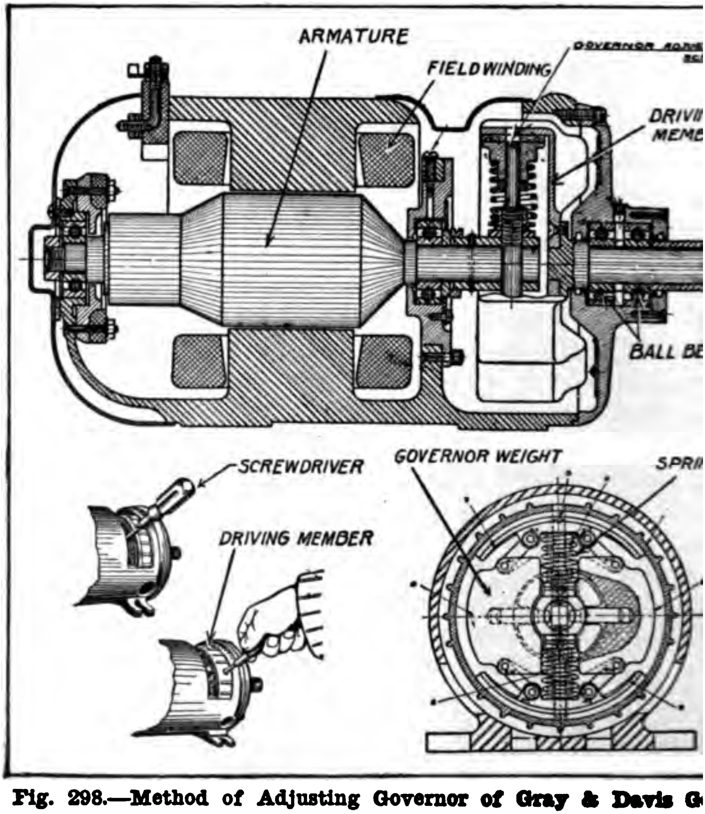


Fig. 298.—Method of Adjusting Governor of Gray & Davis G Dynamo.

cranking speed the starting motor-generator unit automati- changes from a generator to a motor and turns the gasoline ıe crankshaft, making it practically impossible to stall the ıe with this type of starter.

wing to the large amount of current starting switches must r, they are made much heavier in construction than lighting hes. They must be mechanically strong and the contact areas ıfficiently large to pass a current of from 40 to 200 amperes, nding upon the voltage of the starting system and the size of ngine to be turned over. If the contact points were not of area they would be very soon burnt. There are two types of ing switches in common use, one has only a single contact and ed on those systems in which the motor is connected at once tly to the battery terminal. The other type of switch has two of contacts, the first one completing a circuit through a re- nce, the second one cutting out this resistance and permitting naximum current to flow. The Gray & Davis laminated switch, n at Fig. 300, A, is a two-contact form. A movement of the h actuator first engages the blades with the contacts E E, then rched contact piece L makes a connection with the pieces C C low the maximum current to pass. With the switch shown at hich is also of Gray & Davis manufacture, there are no start- gears, and the only necessary operation is to direct the current tly from the battery into the starting motor winding. The h is set in the floor boards of the car and is operated by the rod P, which terminates with a button. The contacts C and e circular in form and their free ends are turned away from other so they may slip down over the members R and S, which et in the insulating piece B. As soon as the pressure of the is released a spring returns the push button P and the electric ıit is broken.

he switch used on some of the Delco systems is shown at C. he latest form the motor generator has two independent wind- both on the field and the armature. If the current from the ery is directed into the generator end the machine acts as a t motor and the armature rotates at a moderate speed. If the ing gearing will not mesh immediately when brought together

a starting button on the dashboard enables the operator to p current through the generator winding, this causing the ar to turn over and facilitating meshing of the gearing. Th starting switch has only two points. In the off position the

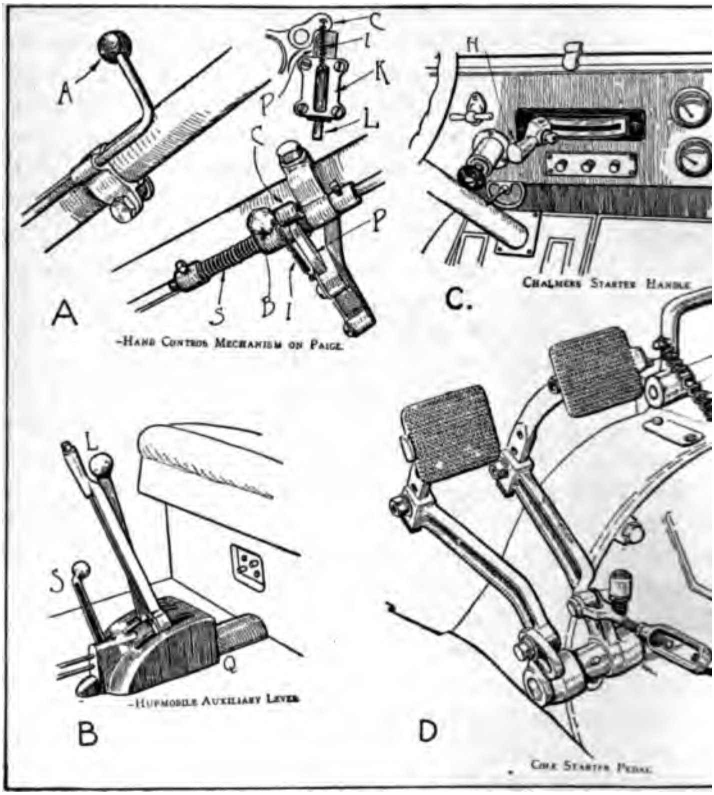


Fig. 299.—Conventional Method of Engaging Starting Gearin

is connected directly to the battery terminal. An auxiliary c on the starting switch breaks the circuit through the generat and stops the current flowing when the device is used as a st motor. A heavy copper bar is moved across the face of th tacts B, E and F, the switch normally connects E and F, a f

which is necessary because of the dual functions of the combined motor generator. When the copper bar is moved to the left contacts B and F are brought into full electrical connection with one another and the entire battery current then flows to the motor. The contact pieces are molded into a piece of insulating material. The contact bar is pressed against them by means of springs.

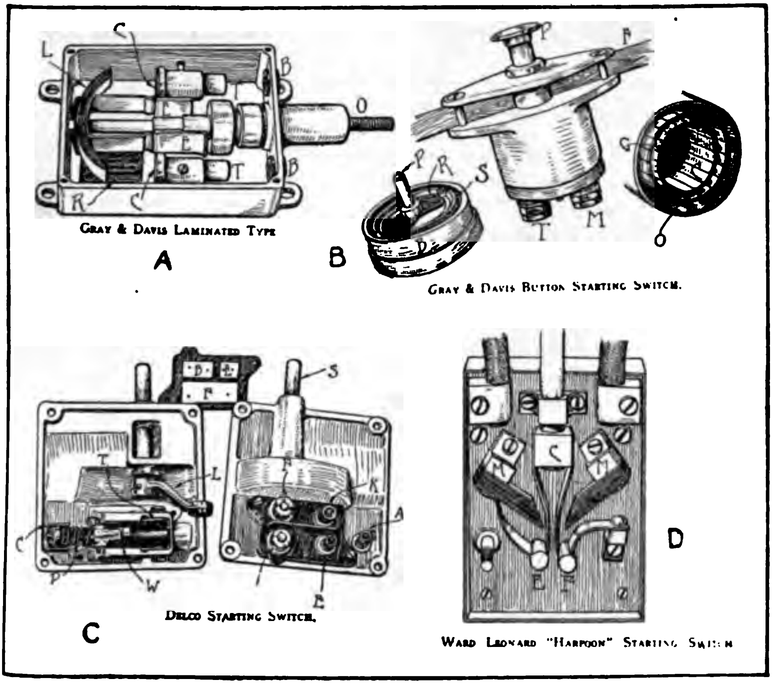


Fig. 300.—Showing Construction of Typical Motor Starting Switches.

Another form of laminated spring switch, which is known as the arpoon type, is shown at B. This is of Ward Leonard design. It designed for use with a starter having flywheel gear drive, thereore it provides two contact points. The first contact with resistnce in circuit is secured when the fingers C contact or make connection with the plugs E and F. Further movement of the switch hort circuits the resistance by closing the main laminated con-

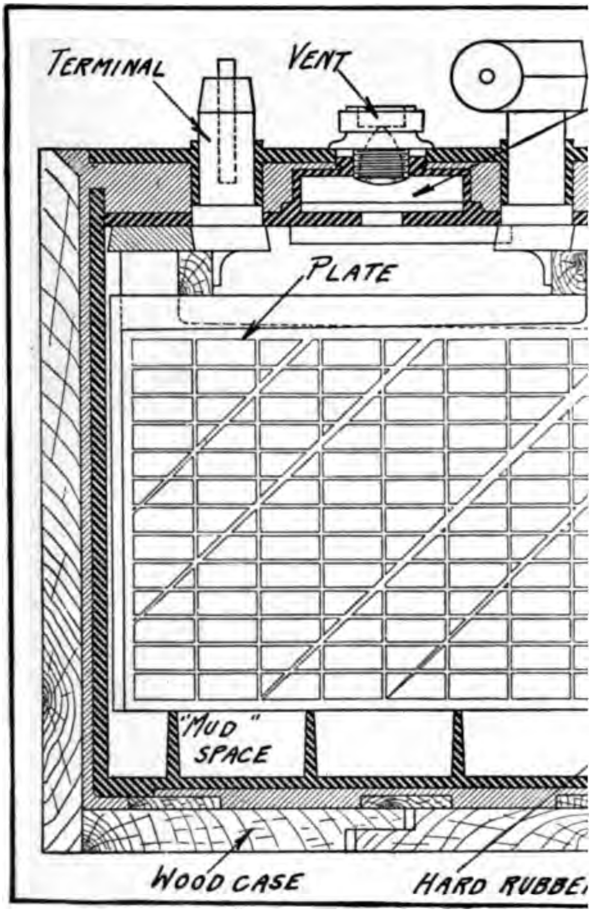


Fig. 301.—Sectional View, Showing Construction of H age Battery Intended for Use With Motor Star Systems.

tacts M M. These allow for considerable latitu The entire switch is built up on a piece of slate resistance coils of wire are placed in the back o The switches shown may be considered repre *though* the construction varies with practically e

IMM.

writer is indebted to the Horseless Age for the illustra-
gs. 299 and 300.

l **Wiring Diagrams, Delco System.**—The various com-
the Delco starting, lighting and ignition system have
ied in the preceding chapter on ignition. A wiring dia-
e Delco-Olds system is shown at the top of Fig. 302 for
a sufficient knowledge of electricity to be able to trace
; wires. All of the units are shown in diagram form, but
on of the system may be easily understood if the descrip-
ias been previously given is studied in connection with
n. The ignition system will draw its current either from
dry battery or from the storage battery. The function
tion relay has been previously described. It will be ob-
t this system operates on the one wire method, all con-
r return of current to the storage battery and the various
; made by the motor car frame. The broken lines indi-
und connection, while the full lines designate wires.
g the starting connections first, it will be apparent that
terminals of the storage battery is grounded to the frame,
e other is joined to one of the terminals of the starting
he other terminal of the starting switch is joined to the
f the motor generator, which makes that device act as
turn the engine crankshaft. The return from the mo-
gs to the storage battery is by means of a grounded re-
With the switch in the position shown, the starting
re not connected with the storage battery, but the gen-
dings are. One of the generator terminals is joined di-
he frame. The other passes through the cutout relay
gh the voltage regulator, both of which have been pre-
scribed. Six of the terminals on the distributor head,
for ignition, are joined to the spark plugs. The remain-
al, which is in the center of the group, is joined to the
terminal of the ignition coil. The circuit through the
is completed through a grounding wire, which is in elec-
act with the grounded bodies of the spark plug. The
erminals of the spark plug are joined to the six terminals
ributor head. The primary winding of the ignition coil

is joined to the circuit breaker through one terminal, this in t passing through the dry battery to the ignition relay. The o terminal of the ignition coil is joined to the **starting, lighting** ignition switch by a suitable conductor.

The arrangement of this switch is such that the current **may** supplied directly to the head, side and tail lamps from the **sto** battery at all times that the switch circuit is closed. It is **also** sible to draw the ignition current either from the six-volt **sto** battery or from the battery of dry cells. The only time that storage battery current flows through the starting motor **windi** is when the starting switch closes the circuit between the **sto** battery and the motor. At all other times the starting switch ber is in such a position that the generator windings are in and that the current from the armature is being passed into storage battery.

Delco Motor Generator.—The motor generator which is lo on the right side of the engine is the principal part of the D System. This consists essentially of a dynamo with two field ings, and two windings on the armature with two commutators corresponding sets of brushes, in order that the machine may both as a starting motor and as a generator for charging the batt and supplying the lights, horn and ignition. The ignition a ratus is incorporated in the forward end of the motor gener This in no way affects the working of the generator, it b mounted in this manner simply as a convenient and acces mounting.

The motor generator has three distinct functions to perf which are as follows: No. 1—Motoring the Generator. No. Cranking the Engine. No. 3—Generating Electrical Energy.

Motoring the Generator.—Motoring the generator is acc plished when the ignition button on the switch is pulled out. allows current to come from the storage battery through the meter on the combination switch, causing it to show a disch The first reading of the meter will be much more than the rea after the armature is turning freely. The current dischar through the ammeter during this operation is the current requ to slowly revolve the armature and what is used for the igni

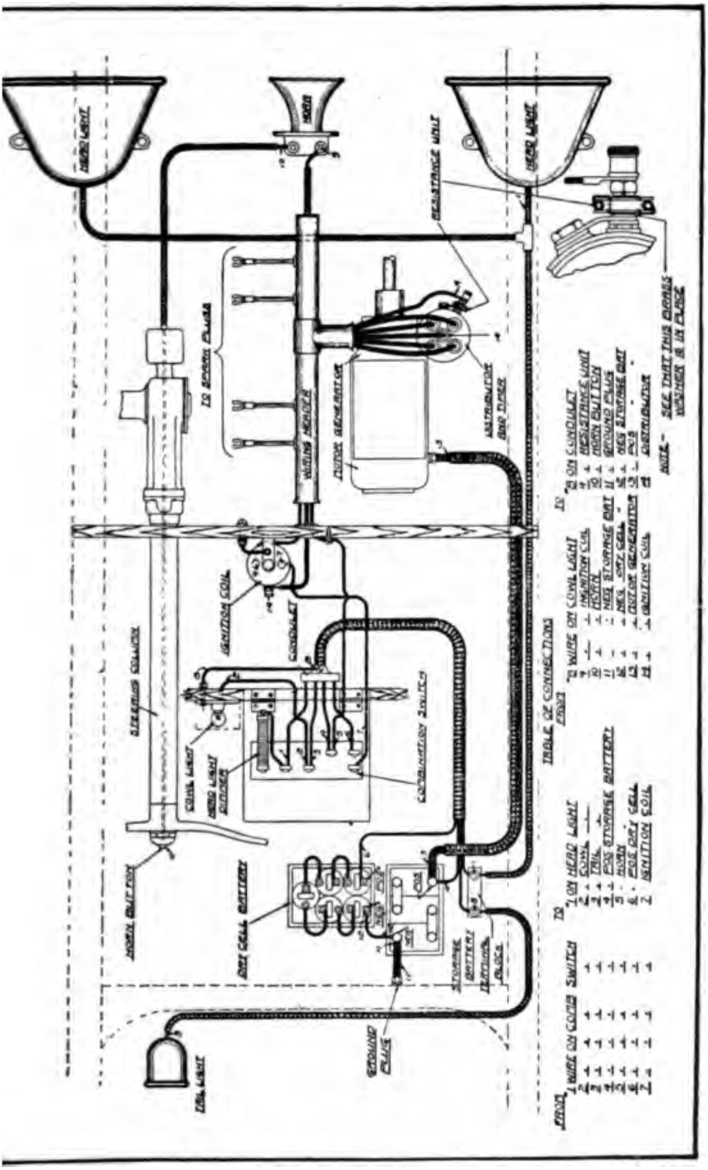


Fig. 303.—Wiring Diagram of Delco-Olds System in Non-Technical Form.

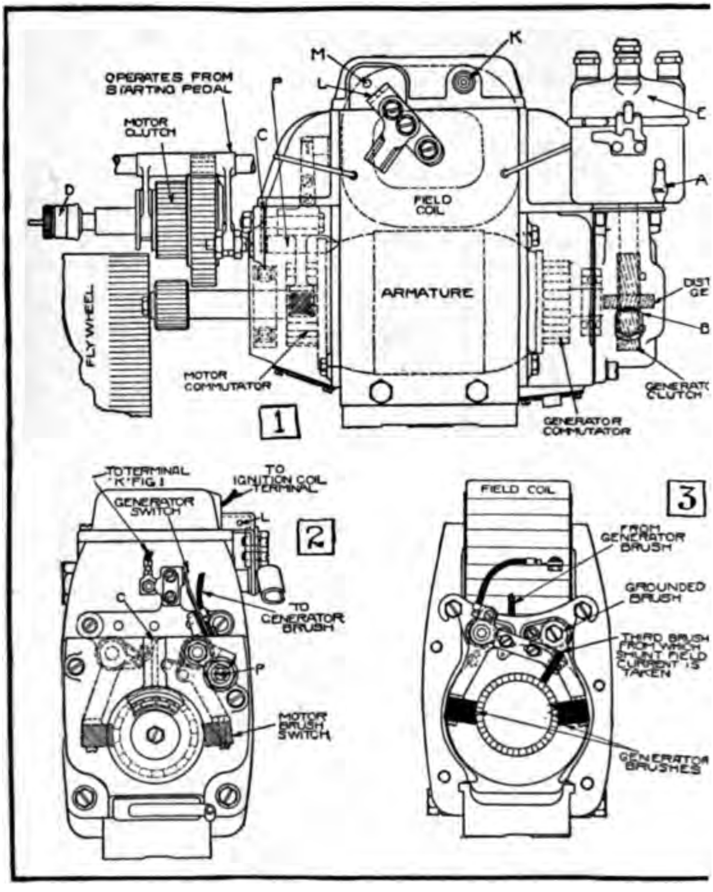


Fig. 303A.—Views Showing Arrangement of Parts of Delco Nun Motor-Generator. Note Double Commutator and Two Sets of Br

The ignition current flows only when the contacts are closed, an intermittent current. The maximum ignition current is (when the circuit is first closed and the resistance unit on t end of the coil is cold. The current at this time is approx 6 amperes, but soon decreases to approximately 3½ amperes as the engine is running it further decreases until at 1,000 *tions of* the engine it is approximately 1 ampere.

This motoring of the generator is necessary in order that starting gears may be brought into mesh, and should trouble experienced in meshing these gears, do not try to force them, sim allow the starting pedal to come back, giving the gears time change their relative position.

Generator Clutch.—A clicking sound will be heard during motoring of the generator. This is caused by the overrunning the clutch in the forward end of the generator which is shown view 1, Fig. 303A.

The purpose of the generator clutch is to allow the armature revolve at a higher speed than the pump shaft during the crank operation and permitting the pump shaft to drive the armat when the engine is running on its own power. A spiral gear is on the outer face of this clutch for driving the distributor. T portion of the clutch is connected by an Oldham coupling to pump shaft. Therefore, its relation to the pump shaft is alw the same and does not throw the ignition out of time during cranking operation. This clutch receives lubrication from the that is contained in the front end of the generator which is put at B (view 1). This is to receive oil each week sufficient to br the oil up to the level of the oiler. The arrangement of clutch pa is shown at Fig. 303B.

Cranking Operation.—The cranking operation takes place wl the starting pedal is fully depressed. The starting pedal brings motor clutch gears (view 1) into mesh and withdraws the pin (views 1 and 2) allowing the motor brush switch to make cont on the motor commutator. At the same time the generator swi breaks contact. This cuts out the generator element during cranking operation. As soon as the motor brush makes contact the commutator a heavy current from the storage battery flo through the series field winding and the motor winding on armature. This rotates the armature and performs the crank operation. The cranking circuit is shown in the heavy lines on circuit diagram (Fig. 303J). This cranking operation require heavy current from the storage battery, and if the lights are during the cranking operation, the heavy discharge from the b tery causes the voltage of the battery to decrease enough to ca

the lights to grow dim. This is noticed especially when the battery is nearly discharged; also will be more apparent with a stiff motor or with a loose or poor connection in the battery circuit or a nearly discharged battery. It is on account of this heavy discharge current that the cranking should not be continued any longer than is necessary, although a fully charged battery will crank the engine for several minutes.

During the cranking operation the ammeter will show a discharge. This is the current that is used both in the shunt field

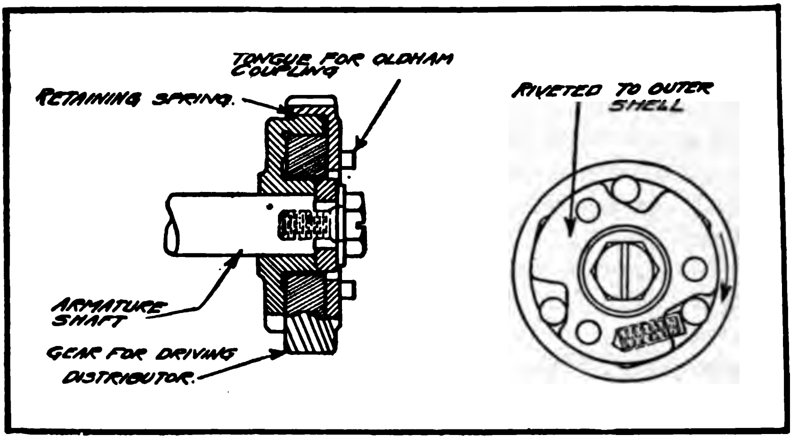


Fig. 303B.—Generator Driving Clutch Only Transmits Power When Engine Speed is Greater Than Armature Speed.

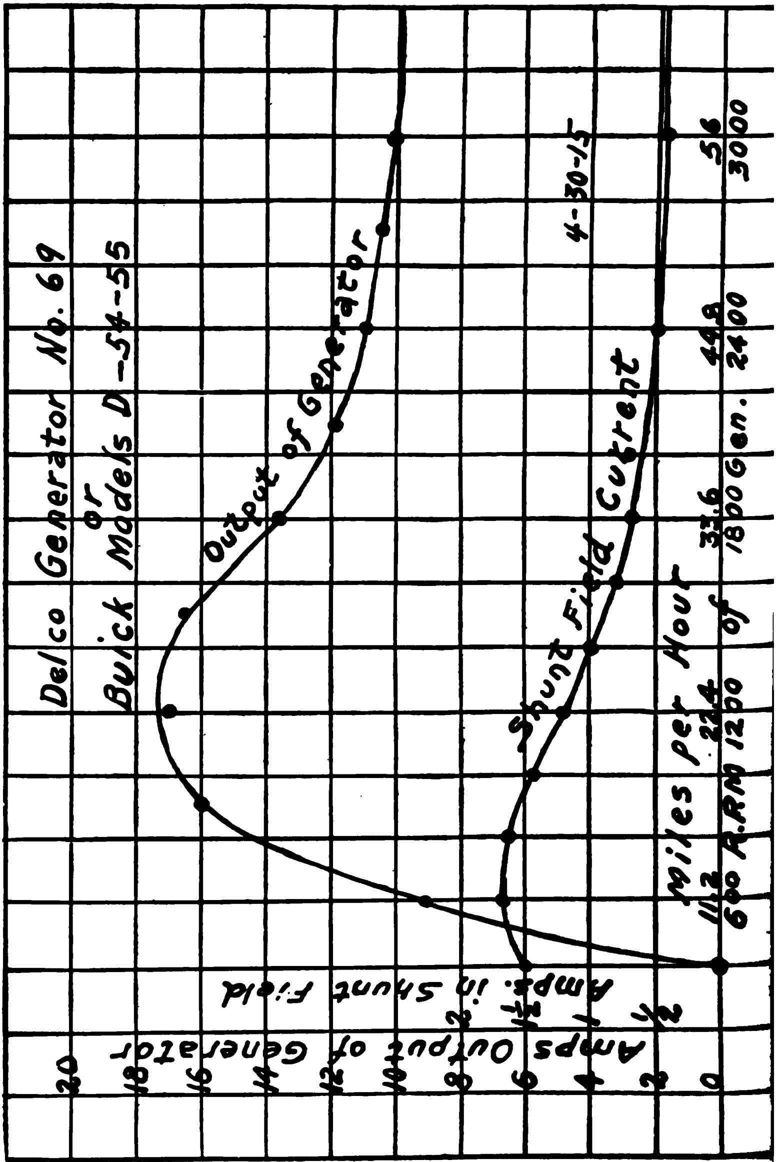
winding and the ignition current; the ignition current being an intermittent current of comparatively low frequency will cause the ammeter to vibrate during the cranking operation. If the lights are on the meter will show a heavier discharge. The main cranking current is not conducted through the ammeter, as this is a very heavy current and it would be impossible to conduct this heavy current through the ammeter and still have an ammeter that is sensitive enough to indicate accurately the charging current and the current for lights and ignition. As soon as the engine fires the starting *pedal should* be released immediately, as the overrunning moto

utch is operating from the time the engine fires until the starting ars are out of mesh. Since they operate at a very high speed, if ey are held in mesh for any length of time, there is enough friction this clutch to cause it to heat and burn out the lubricant. There no necessity for holding the gears in mesh.

Motor Clutch.—The motor clutch operates between the flywheel d the armature pinion for the purpose of getting a suitable gear duction between the motor generator and the flywheel. It also events the armature from being driven at an excessively high eed during the short time the gears are meshed after the engine running on its own power. This cup is lubricated by the grease p A, shown in view 1, Fig. 303A. This forces grease through the llow shaft to the inside of the clutch. This cup should be given urn or two every week.

Generating Electrical Energy.—When the cranking operation finished the motor brush switch is raised off the commutator by pin P when the starting pedal is released. This throws the rting motor out of action. As the motor brush is raised off the nmutator the generator switch makes contact and completes the rging circuit. The armature is then driven by the extension of pump shaft and the charging begins. At speeds above approxi- tely 7 miles per hour the generator voltage is higher than the tage of the storage battery which causes current to flow from generator winding through the armature in the charge direction the storage battery. As the speed increases up to approximately miles per hour this charging current increases, but at the higher eds the charging current decreases. The curve, Fig. 303C, shows proximately the charging current that should be received for ferent speeds of the car. There will be slight variations from s due to temperature changes and conditions of the battery which l amount to as much as from 2 to 3 amperes. The regulation of generator is explained in section 2.

Lubrication.—There are five places to lubricate this Delco Sys- L No. 1—The grease cup for lubricating the motor clutch (D, w 1, Fig. 303A). No. 2—Oiler for lubricating the generator tch and forward armature bearing (B). No. 3—The oil hole) for lubricating the bearings on the rear of the armature shaft.


Delco Generator No. 69
or
Buick Models D-54-55
Output of Generator
Shunt Field Current
4-30-15
Miles per Hour
11.2 22.4 33.6 44.8 56
600 R.P.M. 1200 of 1800 Gen. 2400 3000
Amps Output of Generator
20 18 16 14 12 10 8 6 4 2 0
Amps. in Shunt Field
2 1 1/2

This is exposed when the rear end cover is removed. This shou receive oil once a week. No. 4—The oil hole in the distributor, A, for lubricating the top bearing of the distributor shaft. Tl should receive oil once a week. No. 5—This is the inside of t distributor head. This should be lubricated with a small amou of vaseline, carefully applied two or three times during the fi 2,000 miles running of the car, after which it will require no atte tion. This is to secure a burnished track for the rotor brush the distributor head. This grease should be sparingly applied a: the head wiped clean from dust and dirt.

Method of Current Output Regulation.—The voltage regulat which has been previously described and which was used on t 1914 and 1915 Delco Systems has been replaced by a system "third brush excitation" in the 1916 systems. This has been ve concisely described by the Delco engineers, and in order to ma for accurate presentation of fact, the following descriptive matt is given in the same way as it appears in the Delco instruction boo

There is really only one point in regard to the generating electrical energy which is difficult to understand, and the best scientists are at as much of a loss on this point as the average el trician. This one point can be expressed in the one sentence whi is as follows: "Whenever the strength of the magnetic field or t amount of magnetism within a coil is changed an electro-moti force is induced or generated." This is variously expressed, t can be resolved into the same sentence as originally given. One the most common expressions is, "Whenever an electrical conduct cuts the magnetic field or cuts magnetic lines of force an elect motive force is induced." In order to measure this electro-mot: force, it is necessary to make connection from each end of the c(ductor to a suitable meter, by doing this a coil would be form Therefore, this expression means nothing different from the origii expression. On account of being more readily understood, t expression will be referred to in connection with the explanation the action of the generator.

The amount of the voltage that is induced (or generated) in a conductor or coil varies directly with the rate of the cutting of t magnetic lines; *e.g.*, if we have a generator in which the magn

field remains constant and the generator produces 7 volts at 400 R. P. M., the voltage at 800 R. P. M. would be 14 volts, and it is on account of the variable speed of generators for automobile purposes that they must be equipped with some means of regulation for holding the voltage very nearly constant. The regulation of this generator is by what is known as third brush excitation, the theory of which is as follows:

The motor generator consists essentially of an iron frame and a field coil with two windings for magnetizing this frame. The armature, which is the revolving element, has wound in slots on its iron core a motor winding and a generator winding connected to corresponding commutators. Each commutator has a corresponding set of brushes which are for the purpose of collecting current from, or delivering current to the armature windings while the armature is revolving.

When cranking, current from the storage battery flows through the motor winding magnetizing the armature core. This acting upon the magnetism of the frame causes the turning effort. When generating the voltage is induced in the generator winding and when the circuit is completed to the storage battery this causes the charging current to flow into the battery. The brushes are located on the commutator in such a position that they collect the current while it is being generated in one direction. (The current flows one direction in a given coil while it is passing under one pole piece and in the other direction when passing under the opposite pole piece.) When the ignition button on the combination switch is first pulled out the current flows from the storage battery through the generator armature winding, also through the shunt field winding. This causes the motoring of the generator. After the engine is started and is running on its own power this current still has a tendency to flow in this direction, but is opposed by the voltage generated. At very low speeds a slight discharge is obtained. At approximately 7 miles per hour the generated voltage exceeds that of the battery and charging commences. As the speed increases above this point the charging rate increases as shown by the curve (Fig. 303C). The regulation of this generator is effected by what *is known* as third brush excitation.

'e the magnetic field of the generator is produced by the in the shunt field winding it is evident that should the ield current decrease as the speed of the engine increases ılation would be affected. In order to fully understand this tion it must be borne in mind that a current of electricity has a magnetic effect whether this is desirable or not. Re- to Fig. 303D, the theory of this regulation is as follows: l voltage of the generator is obtained from the large brushes "C" and "D."

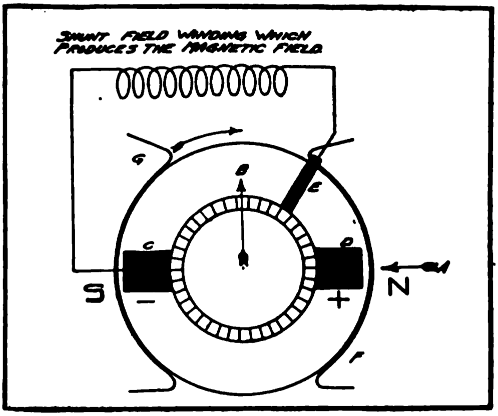


Fig. 303D.—Diagram Illustrating Function of Third Brush In Regulating Delco Generator Output.

ı the magnetic 'rom the pole N and S is not ed by any other ɔe each coil is ing uniformly asses under the eces. The volt- ›m one commu- ›ar to the next practically uni- round the com- r. Therefore, tage from brush rush E is about when the total from brush C to brush D is 6½ volts and 5 volts is applied shunt field winding. This 5 volts is sufficient to cause ap- ately 1¼ amperes to flow in the shunt field winding.

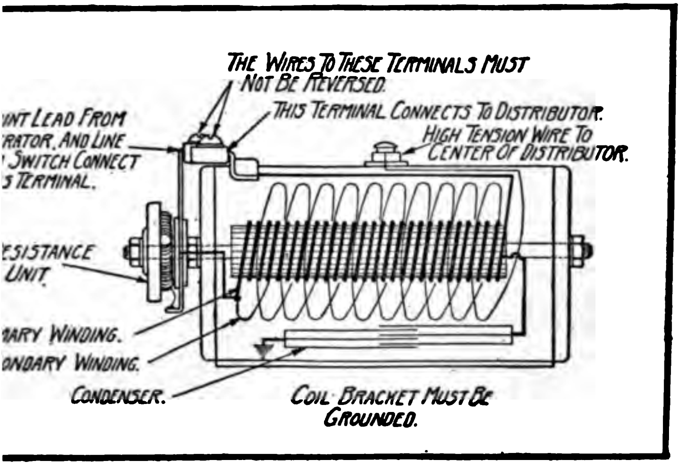
the speed of the generator is increased the voltage increases, ; the current to be charged to the storage battery. This ıg current flows through the armature winding, producing ıetic effect in the direction of the arrow B. This magnetic cts upon the main magnetic field which is in the direction arrow A with the result that the magnetic field is twisted its original position in very much the same manner as two ; of water coming together are each deflected from their l directions. This deflection causes the magnetic field to be

strong at the pole tips, marked G and F, and weak at the oppo pole tips with the result that the coils generate a very low volta while passing from the brush C to the brush E (the coils at th time are under the pole tips having a weak field) and generate greater part of their voltage while passing from the brush E to The amount of this variation depends upon the speed that t generator is driven; with the result that the shunt field curre decreases as the speed increases as shown in the curve.

By this form of regulation it is possible to get a high chargi rate between the speeds of 12 and 25 miles per hour, and it is wi drivers whose average driving speed comes between these limi that more trouble is experienced in keeping the battery charge At the higher speeds the charging current is decreased. The driv who drives his car at the higher speeds requires less current, as exp rience has taught that this type of driver makes fewer stops proportion to the amount the car is driven than the slower driv The output of these generators can be increased or decreased changing the position of the regulating brush. Each time the po tion of the brush is changed it is necessary to sandpaper the bru so that it fits the commutator. Otherwise the charging rate will very low due to the poor contact of the brush. This should not attempted by any one except competent mechanics, and this cha ing current should be carefully checked and in no case should maximum current on this generator exceed 22 amperes. A careful watch should be kept on any machine on which the char rate has been increased to see that the commutator is not b overloaded. Considerable variation in the output of different erators will be obtained from the curve shown, as the output of generator is affected by temperature and battery conditions.

Condenser.—The condenser consists of two long strips of fo tinfoil insulated from each other by paraffined or oiled paper, connected as shown in Fig. 303E. The condenser has the prop of being able to hold a certain quantity of electrical energy, like the storage battery, will discharge this energy if there is circuit between its terminal. As the distributor contacts ope magnetism commences to die out of the iron core, this indu voltage in both the primary and secondary windings of th

ced voltage in the primary winding amounts to from 100 lts. This charges the condenser which immediately dis- self through the primary winding of the coil in the reverse from which the ignition current originally flows. This of the condenser causes the iron core of the coil to be



.—Diagram Showing Internal Wiring of Delco Ignition Coil.

emagnetized and remagnetized in the reverse direction, esult that the change of magnetism within the secondary very rapid, thus producing a high voltage in the second- ng which is necessary for ignition purposes. In addition demagnetizing the coil the condenser prevents sparking aker contacts—thus it is evident that the action of the can very seriously affect the amount of the spark from ary winding and the amount of sparking obtained at the acts.

n Coil.—This is sometimes mounted on top of the motor and is what is generally known as the ignition trans- l. In addition to being a plain transformer coil it has ed in it a condenser (which is necessary for all high nition systems) and has included on the rear end an

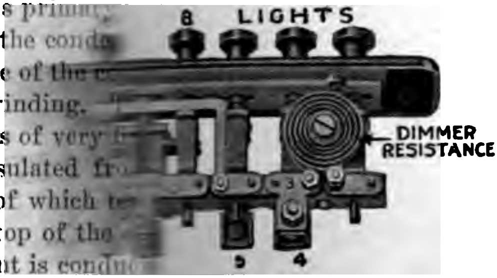
ignition resistance unit. a number of small iron from it is the primary the different parts are is supplied through the coil, through the primary is very plainly shown on interrupting of this primary with the action of the conde tion of the iron core of the in the secondary winding. eral thousand turns of very f which are well insulated fr winding, one end of which te about midway on top of the high tension current is condu tributed to the proper cylinde

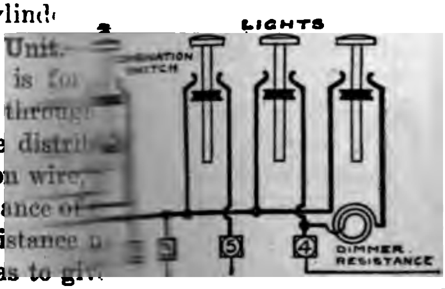
Ignition Resistance Unit. is shown in Fig. 303E is for nearly uniform current throug tion coil at the time the distri a number of turns of iron wire, ably more than the resistance of coil. If the ignition resistance n coil was so constructed as to giv the primary current at low speeds value with serious results to the from the fact that the primary cu of the coil and resistance unit by pedence is the choking effect whic sating current magnetizing the iron as the speed of the pulsation of the unit increases the resistance w

The Cir the circ ombin own in Fi of a

In case the circuit breaker vibrate to increase the tension of the sprin ation of a ground in the system. Re ation will stop.

mmeter on the right side of the com he current that is going to or co



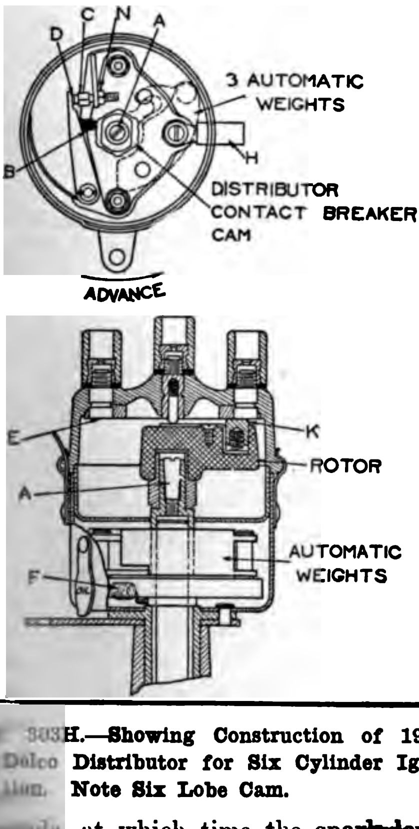


Switch and Circuit Diag

on of the cranking cu nt is being used for li that is being used an as the current is l engine is running used for lights or amount of current nt is being use

...ition and horn in excess of the amount that is being gen- . ammeter will show a discharge as the excess current ...harged from the battery, but at all ordinary speeds the ... read charge. The charging rate for different car ... current is being used for lights or horn, is given ... Fig. 303C.

...on of **Delco Ignition Distributor.**—It is well under- ... mixture burns quicker than a lean one. For this ...ne will ...lvance ...hrot- ...wide ...d in the the ...



...303H.—Showing Construction of 1916 Delco Distributor for Six Cylinder Ignition. Note Six Lobe Cam.

...ds, at which time the spa...ver ...When *the* ignition is to...

it to continue to operate. In case the circuit breaker vibrate
peatedly, do not attempt to increase the tension of the sprin
the vibration is an indication of a ground in the system. Re
the ground and the vibration will stop.

The Ammeter.—The ammeter on the right side of the com
tion switch is to indicate the current that is going to or co

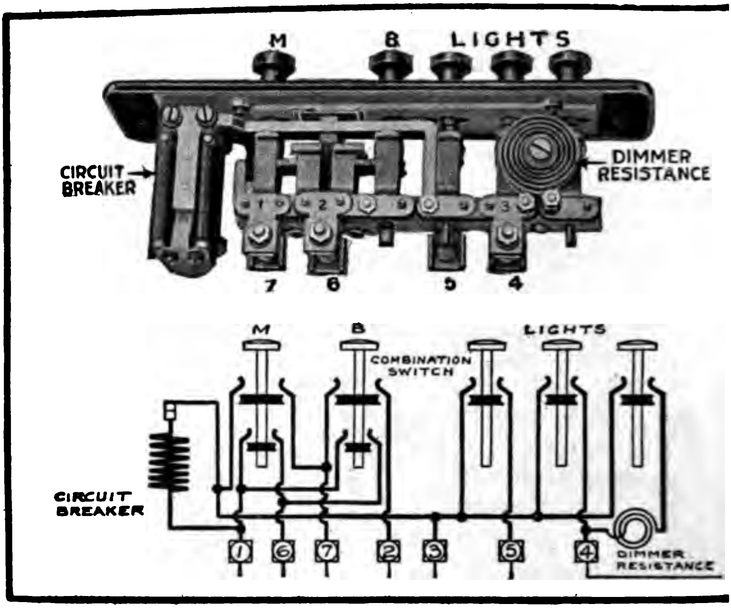


**Fig. 303G.—View of Delco Combination Switch and Circuit Dia
for Same.**

from the storage battery, with the exception of the cranking cu
When the engine is not running and current is being used for l
the ammeter shows the amount of current that is being used an
ammeter hand points to the discharge side, as the current is
discharged from the battery. When the engine is running
generating speeds and no current is being used for lights or
the ammeter will show charge. This is the amount of current
is being charged into the battery. If current is being use

lights, ignition and horn in excess of the amount that is being ge erated, the ammeter will show a discharge as the excess curre must be discharged from the battery, but at all ordinary speeds tl ammeter will read charge. The charging rate for different c speeds when no current is being used for lights or horn, is giv in the curve, Fig. 303C.

Construction of Delco Ignition Distributor.—It is well unde stood that a rich mixture burns quicker than a lean one. For th reason the engine will stand more advance with a half open throttle than with a wide open throttle, and in order to secure the proper timing of the ignition due to these variations and to retard the spark for starting, idling and carburetor adjusting, the Delco distributor also has a manual control. The automatic feature of this distributor is shown in Fig. 303H. With the spark lever set at the running position on the steering wheel (which is nearly all the way down on the quadrant), the automatic feature gives the proper spark for all speeds excepting a wide open throttle at low speeds, at which time the spark lev should be slightly retarded. When the ignition is too far a

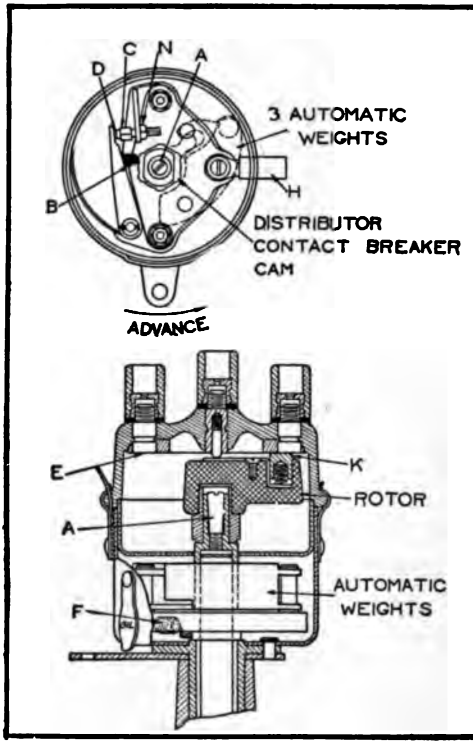
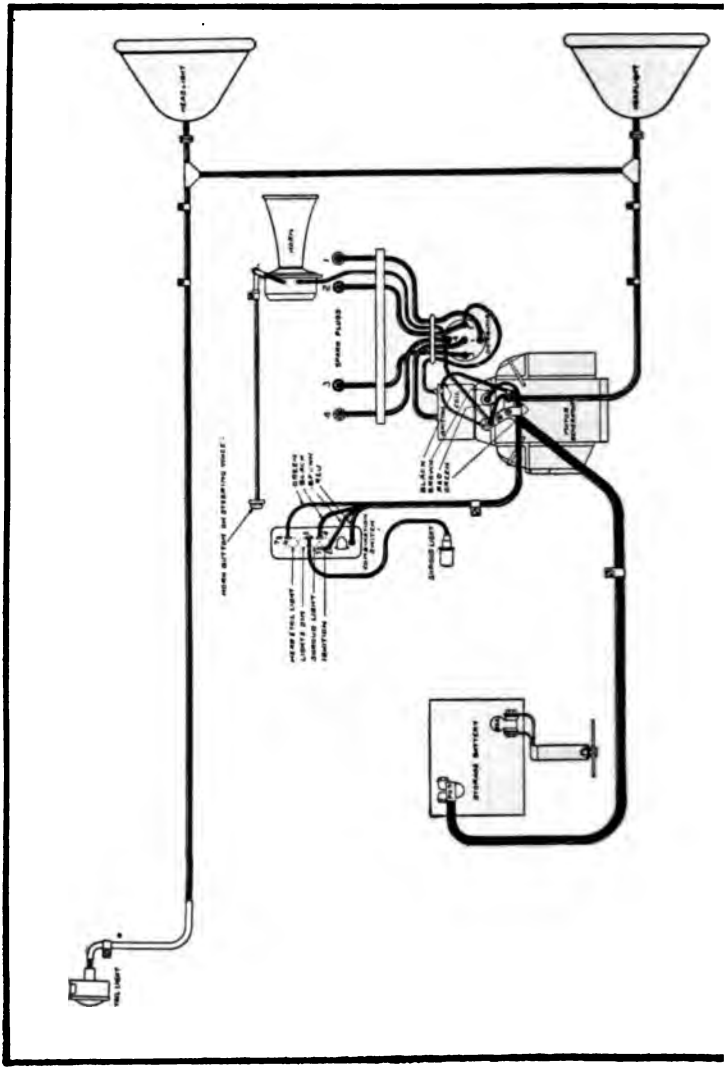


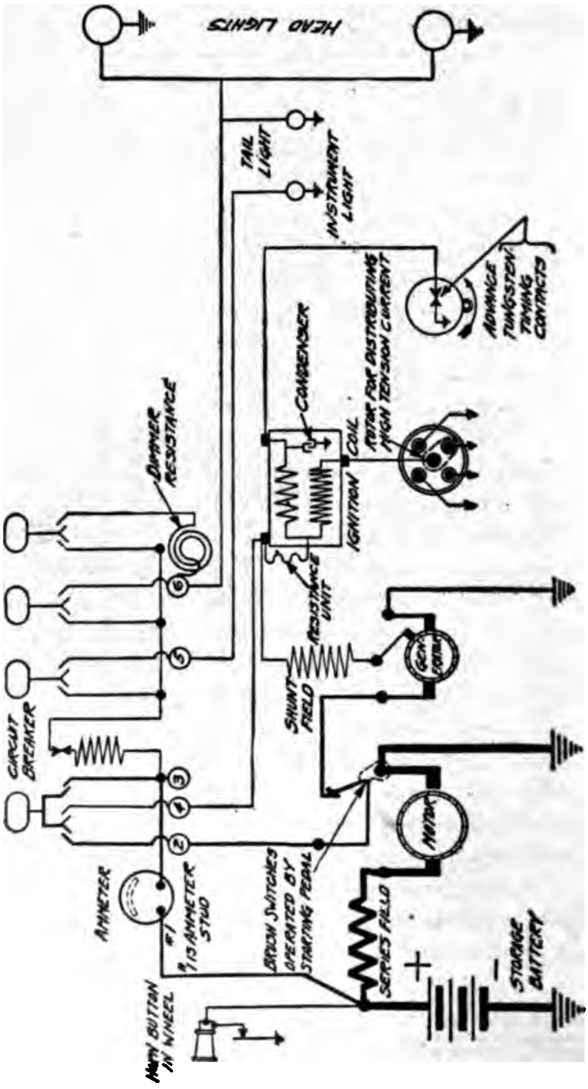
Fig. 303H.—Showing Construction of 19 Delco Distributor for Six Cylinder Ig tion. Note Six Lobe Cam.


SPARK PLUGS
STORAGE BATTERY
HORN BUTTON ON STEERING WHEEL

vanced it causes loss of power and a knocking sound within tl engine. With too late a spark there is a loss of power (which usually not noticed excepting by an experienced driver or one ve familiar with the car), and heating of the engine and excessi consumption of fuel is the result. The timer contacts shown D and C (Fig. 303H) are two of the most important points an automobile. Very little attention will keep these in perfect co dition. These are tungsten metal, which is extremely hard a requires a very high temperature to melt. Under normal conc tions they wear or burn very slightly and will very seldom requi attention; but in the event of abnormal voltage, such as would obtained by running with the battery removed, or with the igniti resistance unit shorted out, or with a defective condenser, these co tacts burn very rapidly and in a short time will cause serious ig tion trouble. The car should not be operated with the batte removed.

It is a very easy matter to check the resistance unit by observi its heating when the ignition button is out and the contacts in t distributor are closed. If it is shorted out it will not heat up, a will cause missing at low speeds. A defective condenser such will cause contact trouble will cause serious missing of the ignitio Therefore, any one of these troubles are comparatively easy locate and should be immediately remedied. These contacts shou be so adjusted that when the fiber block B is on top of one of t lobes of the cam the contacts are opened the thickness of the gau on the distributor wrench. Adjust contacts by turning conta screw C and lock with nut N. The contacts should be dressed wi fine emery cloth so that they meet squarely across the entire fa The rotor distributes the high tension current from the center the distributor to the proper cylinder. Care must be taken to s that the distributor head is properly located, otherwise, the rot brush will not be in contact with the terminal at the time the spa occurs.

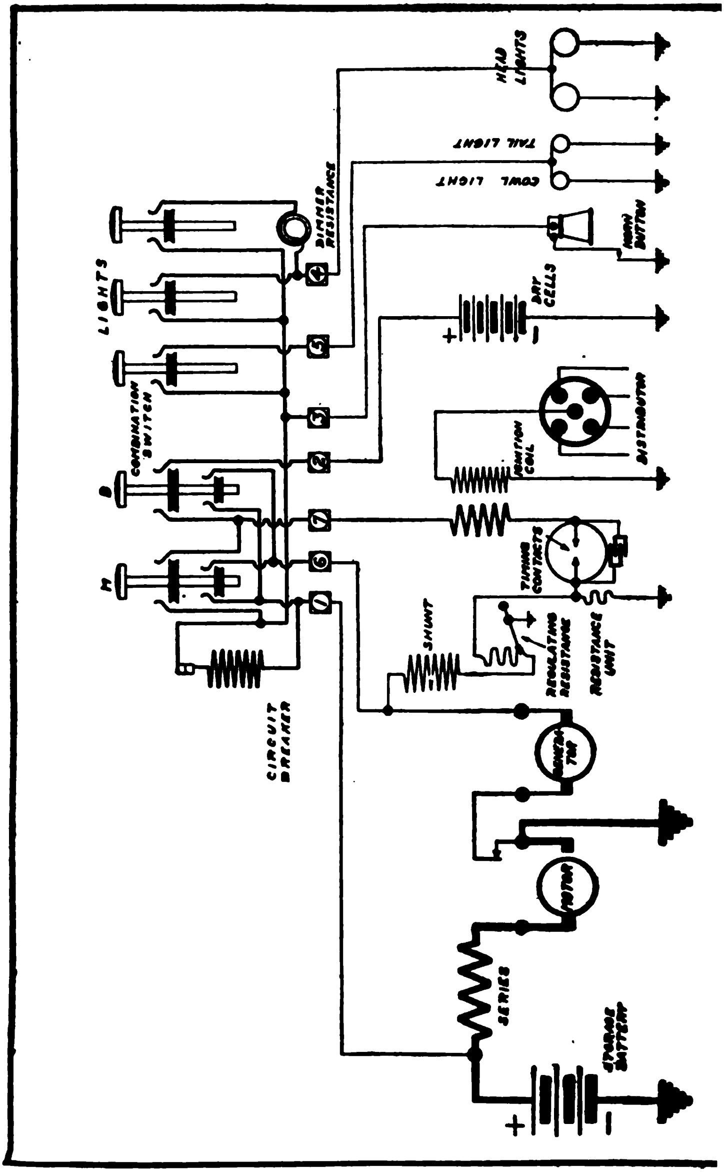
Combination Switch.—The combination switch is located on t cowl board and makes the necessary connections for ignition a lights. The "M" button controls the magneto type ignition a the "B" button, the dry battery ignition. In addition to this bc


HEAD LIGHTS
TAIL LIGHT
INSTRUMENT LIGHT
ADVANCE TUNGSTEN TIMING CONTACTS
ROTOR FOR DISTRIBUTING HIGH TENSION CURRENT
CONDENSER
COIL
IGNITION
DIMMER RESISTANCE
RESISTANCE UNIT
SHUNT FIELD
GEN
MOTOR
CIRCUIT BREAKER
AMMETER
#1 IS AMMETER STUD
BRUSH SWITCHES OPERATED BY STARTING PEDAL
SERIES FIELD
STORAGE BATTERY
HORN BUTTON IN WHEEL

the "M" and "B" buttons control the circuit between the generat and storage battery. When the circuit between the generator a the storage battery is closed by either the "M" or "B" butt on the combination switch, the direction of flow of the current from the battery to the generator when the engine is not runnir as well as when it is running below 300 R. P. M. But the amou of current that flows from the battery at the lowest possible engi speeds is so small that it is negligible. That used on Buick 19 cars is shown at Fig. 303G, the type supplied on 1916 cars is ou lined at Fig. 303F.

To Time the Ignition.—1. Fully retard the spark lever. Turn the engine to mark on flywheel about one inch past de center to the "7 degree" line, with No. 1 cylinder on the firi stroke. 3. Loosen screw in center of timing mechanism and loca the proper lobe of the cam by turning until the button on the rot comes under the high tension terminal for No. 1 cylinder. 4. S this lobe of the cam so that when the back lash in the distribut gears is rocked forward the timing contacts will be open, and wh the back lash is rocked backward the contacts WILL JUST CLOS Tighten screw and replace rotor and distributor head.

Hints for Locating Trouble.—1. If starter, lights and horn a fail, the trouble is in the storage battery or its connections, su as a loose or corroded connection or a broken battery jar. 2. If t lights, horn and ignition are all O. K., but the starter fails to crar the trouble is in the motor generator, such as dirt or grease on t motor commutator, or the motor brush not dropping on the co mutator. 3. If the starter fails to crank or cranks very slowly, a the lights go out or get very dim while cranking, it indicates loose or corroded connection on the storage battery, or a near depleted storage battery. 4. If the motor fires properly on t "M" button, but not on the "B" button, the trouble must be the wiring between the dry cells or the wires leading from the d cells to the combination switch, or depleted dry cells. If the ig tion works O. K. on the "B" button and not on the "M" butt the trouble must be in the leads running from the storage batte to the motor generator, or the lead running from the rear termi on the generator to the combination switch, or in the storage batte


HEAD LIGHTS
TAIL LIGHT
COWL LIGHT
HORN BUTTON
DIMMER RESISTANCE
LIGHTS
DRY CELLS
COMBINATION SWITCH
DISTRIBUTOR
IGNITION COIL
B
TIMING CONTACTS
M
SHUNT
REGULATING RESISTANCE
RESISTANCE UNIT
CIRCUIT BREAKER
GENERATOR
MOTOR
SERIES
STORAGE BATTERY
4
5
3
2
7
6
1
+
-

itself, or its connection to the frame of the car. 5. If both syste of ignition fail, and the supply of current from both the stora battery and dry cells is O. K., the trouble must be in the co resistance unit, timer contacts or condenser. This is apparent fr the fact that these work in the same capacity for each system ignition.

Never run the car with the storage battery disconnected, while it is off the car. Very serious damage to the motor-generat may result from such action.

Never remove any electrical apparatus from the car or ma any adjustments without first disconnecting the storage batte This can be done most conveniently by removing the ground co nection. Remember, a loose, corroded or dirty connection on t battery can put both starting and lighting systems out of comm sion.

Bijur-Packard System.—The self-starting and lighting syste Fig. 302, used on the Packard, is manufactured by the Bijur M tor Lighting Co. In this system the starting motor and generat are separate units. The starting circuit is simple, consisting of motor connected directly to the battery and operated by closing starting switch.

In the generator circuit the principal parts are: The generato an automatic switch for breaking the circuit when the speed of t generator becomes so low that the battery current would dischar through it, and a voltage regulator of the vibrator type. A stu of the wiring diagram shows that the automatic switch has t coils, a voltage coil of high resistance connected across the wi leading to the battery and a current coil in series with the gene tor and battery. The action of this coil is such that as the arm ture speed increases and the voltage becomes greater, the magn ism generated in this coil attracts a small steel arm, thus completi circuit between the battery and the generator. Current then flo to the battery and lights.

On the other hand, as the speed of the generator decreases, voltage becomes less and finally a point is reached where the cu rent begins to flow back into the generator. This reversal of fl produces a magnetic field in the series coil of the cutout wh

opposes the field produced by the voltage coil, until finally th traction of the latter for the steel arm that completes the circu entirely overcome and then the arm, impelled by a spring, br contact.

The voltage regulator operates on the vibrator principle, ar designed so that when the voltage becomes higher than the pred mined amount the vibrator throws a resistance into circuit tha duces the amount of current flowing through the field. Thi minishes the voltage. When the voltage becomes too low, the vi tor flies back again and allows full current to pass through the once more. The movement of this vibrator is extremely ra making about 150 oscillations per second, so that in actual p tice, no change in voltage, in one direction or the other, is notice

Now looking at the diagram, it is seen that this regulator sists of a vibrating arm which is actuated by an electro-magnet nected across the mains running from the generator. When arm is not attracted by the magnet, full field current is allowe flow through wire A from one generator lead up through the sl field to the other lead of the generator, thus full field streng obtained and a rising voltage is generated, which finally cause magnet coil to pull this arm out of contact, thus breaking the cuit. When this occurs, the current must flow to the field thr the resistance B, and this resistance reduces the flow of the cur and weakens the field so that the generated voltage drops. reduction in voltage causes a smaller current to flow through magnet winding and then the attraction of the magnet weal allowing the arm to fly back, thus enabling full current to through the field again. This cycle is repeated 150 times a sec Special provision has been made so that the contact points on regulator will not burn away.

There is nothing unusual in the wiring, which may be e followed from the diagram.

Hartford Starting System.—The wiring diagram at Fig. shows clearly the method of connecting the various applia forming part of the Hartford starting and lighting system. is a 12 volt, two wire starting system, with a connection so *lamps* receive their current from the battery on the three wire

tem. The two terminals of the generator are connected to the stor age battery in the usual way, one directly to a terminal, the othe through the automatic cutout. When the knife-switch is closed, th battery current flows through the motor windings and turns th engine crankshaft. The connections are so clearly shown tha further description is unnecessary. The speed of the generato armature is governed by the centrifugal governor, which is de signed to keep it at 1200 revolutions per minute. The lightin switch is of the selective barrel type, having three positions of th handle, one of which will give the head and rear lamps, the inter mediate position lighting the side and rear, while the last positio sends the current through all the lamps. This switch is not show in the diagram.

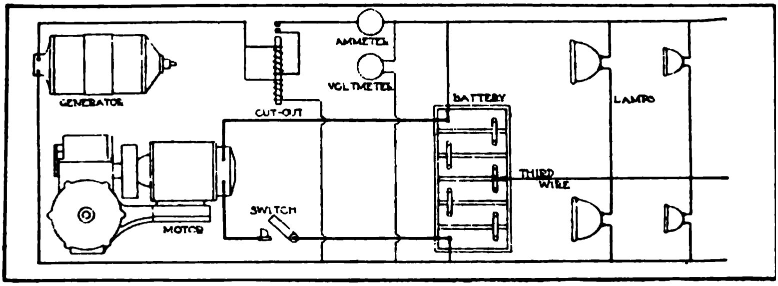
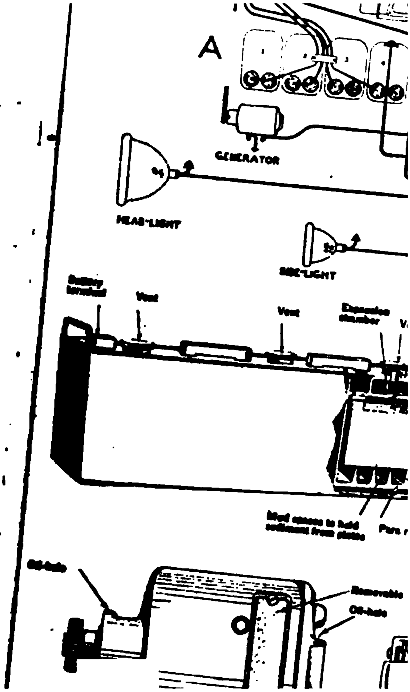


Fig. 304.—Wiring Diagram of Hartford 12 Volt Starting System, Having Three-Wire Method of Supplying Current to 6 Volt Lamps.

The Auto-Lite System.—The 1915 Overland cars use the Autc Lite system, which is shown at Fig. 305, A. This is a six volt, thre unit system, operating on the one wire principle. The ignitio function is performed by an entirely distinct appliance from th starting and lighting systems, namely, a high tension magnetc Five wires run from this magneto, four of these running the spar plugs, one for interrupting the ignition through a fuse box to th controlling switch. The generator is driven from the motor crank shaft by a silent chain. The starting motor, which has the switc mounted integrally, turns the engine crankshaft through a gear cu on the flywheel rim. One of the wires of the generator is groundec


A
GENERATOR
HEAD-LIGHT
SIDE-LIGHT
Battery terminal
Vent
Vent
Expansion chamber
Mud spaces to hold sediment from plates
Oil-hole
Removable
Oil-hole

'emaining wire leading from that device runs through the cir- breaker and from that member through the fuse box and :h to the storage battery. Two wires run from the six volt ·ry, one of these terminating on a switch terminal of the start- motor while the other attaches to one of the motor terminals. remaining motor terminal is grounded. The various appli- s comprising this system are all clearly shown, and the wiring be easily traced from the various units through the fuse box switch by careful study of the diagram. In order to simplify ng, the wires going to the switch are all colored differently. insures that they will be replaced on the proper terminals if oved.

The storage battery used with this system is shown at Fig. 305, It is a special form, in which the three cells are placed end to instead of side by side, making a long, narrow battery instead ıe usual construction, which is approximately square. The con- ction of the circuit breaker is shown at C, the contact points, :h are the only parts needing attention, being clearly outlined. generator, which is a very simple device, is shown at B, the ts requiring lubrication, and the removable plates for inspec- of the brushes are clearly depicted. The starting motor is ·n at E, the pinion which engages the gear on the flywheel is ·n mounted on the armature shaft, and the cover, which nor- y covers the brush end of the motor, is removed in order to · the method of reaching the motor brushes when these members l attention.

Gray & Davis System.—The starting and lighting equipment l on the Model 79, 1914 Overland, is the Gray & Davis system, ·n at Fig. 306, and comprises three principal units:

ı—The generator which produces the current and delivers it to lamps and storage battery.

›—The storage battery which accumulates the current thus gen- ed and delivers it to the lighting system or the starting motor, ccasion demands.

;—The starting motor, which receives current from the storage ery and revolves the engine whenever it is to be set in motion.

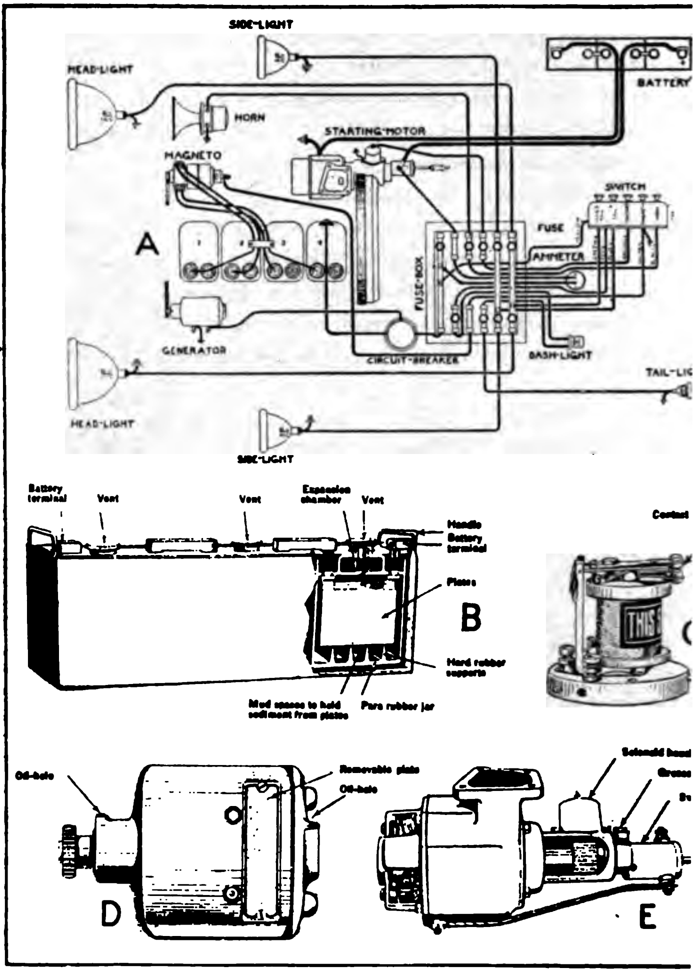


Fig. 305.—Complete Wiring Diagram of Starting and Lighting
Used on 1915 Overland Automobiles at A, Part Sectional V
Storage Battery at B, Design of Circuit Breaker Shown at
ternal View of Generator at D, and Starting Motor Cons
at E.

Besides these three principal units the system includes the fol-
wing auxiliary apparatus:

d—An automatic cutout, whose function is to disconnect the
nerator from the storage battery when the engine is stopped or
inning below the speed at which the generator's voltage is high
iough to charge the battery. The cutout is located on the engine
de of the dash.

e—The starting switch, which is a pedal-button located in the
or board of the car convenient to the foot of the operator.

f—The ammeter, whose purpose is to show whether the system
working properly or not. When the dynamo is running and
nding current to the storage battery the ammeter hand will point
the right of zero or at "charge." When the lights are burning
the starter motor is running, this hand will point to the left of
ro or at "discharge," thus indicating the rate at which current
going out of the storage battery.

The speed of the generator is controlled by an automatic clutch
at is so designed that, no matter how fast the engine runs, the
nerator will not be driven faster than a certain predetermined
eed which corresponds to that at which the engine runs when
iving the car at 12 miles per hour on high gear, but, of course, if
e engine drops below this speed the generator will also. This is
ne by means of a centrifugal governor which regulates the slip-
ige of the clutch so that the generator cannot be driven faster
an the predetermined speed, the greater the speed of the engine
e more the clutch slips.

The current load is automatically taken care of by a compound
inding on the generator. The starting motor is a series wound
achine, that is, the entire armature current passes through the
ld. The motor is provided with an over-running clutch, which
lows it to drive the engine but automatically disengages when
e engine starts so that the engine will not drive the motor. If
ch a device were not fitted the generator might be injured by the
otor driving it at too high a speed.

As already explained, the function of the automatic cutout is
disconnect the generator from the battery when the engine is
opped or turning so slowly that its voltage is below that of the

attery. If this cutout were not provided the storage bat
lischarge back into the generator.

The cutout consists of an electro-magnet with tw
One is a shunt winding of many turns of fine wire a
a series winding of a few turns of heavy wire, both w
over a soft iron core. The shunt winding is permane
across the positive and negative terminals of the ger
when the generator comes up to charging speed, thi
gizes the magnet core and the magnet core attracts
closes the circuit between the generator and the b
closes the circuit between the cutout points are closed the c

So long as the cutout points are closed the c
through the series winding of the cutout. This
magnetizing influence to that of the shunt win
points together. The cutout is designed so tha
speed of 12 miles per hour and opens at 10.

If, now, the speed of the generator drops b
the current begins to flow through the cutout
reverse direction. This weakens the pull an
fly apart, through the agency of a spring.

Now that a general idea of the differer
Davis system has been obtained, the path o
ferent wires will be explained. The illu
tem with a very complete equipment. Be
and tail lights, there are pillar lights, d
light and an electric horn connection.
return circuits are through the frame
connections between the storage batter

First we will trace out the flow o
switch is closed, this circuit being sh
Current flows from the plus termin
through wire A to the motor, whe
field and the armature and from th
starting switch and from ther
pole of the battery.

Below 9 or 10 miles
... open and th

CA

ne and Two

to th
to th
switch
P, an
genera
it, an
he ar
switc
y wi
clos
stora
are

volta
s v
l a
int
of
l f
fr
th
ci
ir
or
h

battery
dischar
The
One is
a series
over a s
across t
when th
gizes th
closes t
So
through
magnet
points
speed c
If,
the cur
reverse
fly apa
Nov
Davis s
ferent
tem wi
and tai
light a
return
connect
Fir
switch
Curren
throug
field ar
startin
pole of
Bel
cutout
nished

wire A to one terminal of the starting motor, where it goes to t frame through the ground wire Z. From thence it runs to t lamps. From the lamps the current passes to the junction swit where all the lamp terminals are connected to the terminal P, a from here the current flows through the series field of the gene tor and on out through wire F to a terminal on the cutout, a from thence to the ammeter over the short wire E. From the a meter it goes via wire D to a binding post on the starting swit from which it connects with the other pole of the battery by w C. At or over 12 miles per hour the cutout contact points are clos as previously described. Current is then supplied to the stora battery if it needs charging and also to any of the lamps that are circuit.

If the battery needs recharging it is of course below the volta of the generator and therefore current will flow to it until its vo age becomes equal to that of the generator, when the flow will au matically stop because the electrical pressure at the two points the same. The current passes from the positive terminal of t generator through wire G to the series coil of the cutout and fr thence through wire Y to the frame. It flows through the fra up through wire Z to one terminal on the motor and from the through wire A to the plus pole of the battery. The return circ is through wires C and D to the ammeter and from thence throu wires E and F back to the generator. The flow of current from generator to the lamps is as follows: Through wire G and the ser coil of the cutout and wire Y to the frame. This part of the c cuit is identical with that for charging the storage battery. Th the current goes through the frame and up through the grou wires to the lamps, from whence it passes to the terminals on junction switch and on through wire P to the generator. It v be noted that the generator and battery circuits to the lamps independent, so that should anything happen to the battery, lights could be operated by the generator alone. Diagrams of Gr & Davis 1915 systems will be found on folding plate, Fig. 307, both non-technical and technical form.

A number of parts comprising the 1915 Gray & Davis start system is shown at Figs. 308 and 309. The construction of

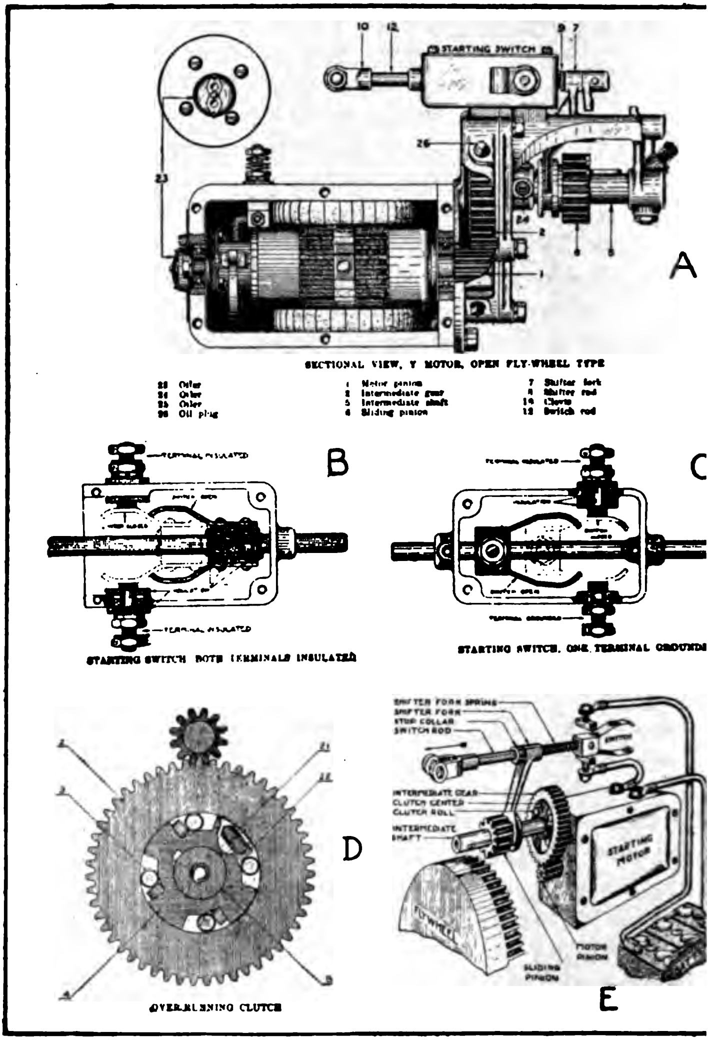


Fig. 308.—Starting Motor and Switch Details Used in 1915 Gray & Davis Starting System.

pe Y motor used in connection with engines of the open flywheel pe is clearly shown in the part sectional view at the top of the lustration. As the Gray & Davis systems may be had in either e one wire or two wire type, two forms of switch are provided. ne of these, which is shown at B, Fig. 308, is used in a two wire stem and has both terminals insulated. This must be wired up as own at E. The heavy leads from the storage battery are concted as indicated. One of the storage battery terminals is concted to the terminal on the starting motor, while the other start-g motor terminal wire goes to one of the insulated switch termials. The other insulated switch terminal is connected directly to e remaining storage battery terminal. When used in connection ith the one wire system the starting switch has one terminal ounded, as shown at C.

The approved arrangement of the starting switch is as depicted the top of the illustration, in which the contact is not establhed until the sliding pinion has been meshed with the gear of e flywheel. The construction of the overrunning clutch used with e Gray & Davis system is shown at D. This functions the same the overrunning clutch previously described, the drive being sered between the member 4, which is keyed to the intermediate aft, and the reduction gear 2, which is turned by the motor pinn 1 through the medium of the clutch rolls 3. Light coil springs e employed to push plungers, designed to make more positive the gagement of the rolls of the overrunning clutch.

The fuse block, which is an important adjunct of the one wire stem, is combined at the rear of the lighting switch, as shown at , Fig. 309. The function of the fuse is to burn out should an erload occur in any circuit due to damaged insulation. The ses are readily renewable, these being shown at D. The fuse consts of a glass tube, which contains a piece of fusible alloy wire at joins two metal caps, these caps being used to establish conct with the clips on the sides of the connectors at the back of the itch. The fuses should be handled carefully, and in removing me for examination it is well to do this with a sharp piece of ood, which is used as a pry back of the fuse instead of attempting remove them with pliers or a screwdriver, which may break the

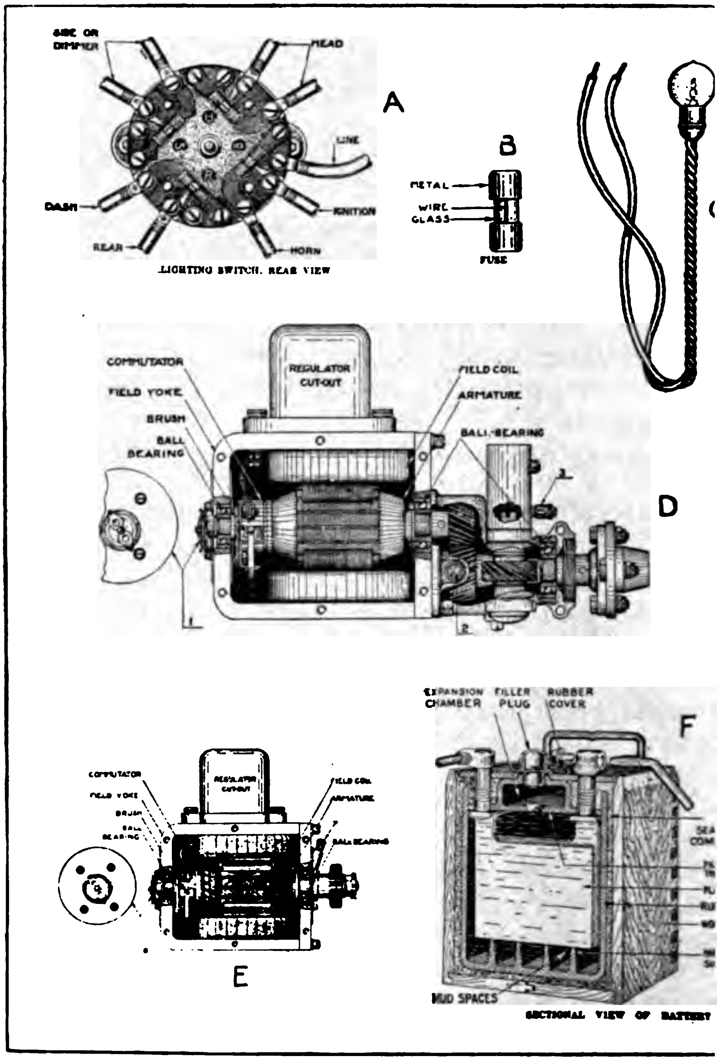


Fig. 309.—Generator and Battery Construction Used in Gray & 1915 Lighting and Starting System.

s or otherwise damage the fuse. An important adjunct to assist ocating trouble is a six volt lamp, such as shown at C. This is naterial assistance in tracing circuits.

The latest form of Gray & Davis dynamo, which dispenses with centrifugal governor used on the other types illustrated, is wn at D, supplied for direct drive by an extension of the timing r shaft and for chain drive at E. The dynamo shown at D rovided with gearing to drive a timer distributor for ignition poses. The current supply is governed by the regulator cut-, which performs two duties in the new systems. One of these o regulate the dynamo to secure uniform current output, while the other instance it connects the dynamo into the system only en sufficient current is generated to charge the battery. Cur-t regulation is provided by short circuiting or shunting field re-ances or to insert the field resistances into the field circuit. The ect of the field resistance is to retard the flow of current in those dings. When the dynamo is at rest the cutout points are opened l the regulator points closed. As the dynamo first speeds up the ulator points remain closed and the field resistance is short cir-ted. This permits the dynamo to build up its full field strength. en the proper voltage is reached the cutout points close, permit-g current to flow through the series winding to the system. As dynamo speed increases beyond that necessary for full output, pull of the shunt winding attracts the regulator armature. s reduces the pressure at the regulator points and inserts a re-ance into the field circuit, this preventing further increase of put. The frequency with which the resistance is put into the cuit is in proportion with the amount of speed variation. The m of battery used with the Gray & Davis system is shown in t section at F, Fig. 309. It does not differ materially in struc-e from types previously described.

Locating Troubles in Gray & Davis System.—In event of trou-with the Gray & Davis lighting system, the makers recommend areful study of the symptoms, which will usually provide a de to find the component at fault. The indicator on the dash ws positively any failure of the generator or any break in the ing. If the indicator does not indicate "charge" when the en-

gine is speeded up but shows "discharge" when lights are on and the engine at rest, the dynamo or current regulato working properly. A common trouble is the dynamo brus sliding freely in their holders. If the dynamo is driven by belt this may be too loose to drive the dynamo at propei If the indicator does not indicate "charge" with the engine up and does not indicate "discharge" with the lights on engine at rest, one should look for an open circuit or lo nection in the battery wiring or for corrosion or looseness storage battery terminals. Sometimes the dynamo termin have loosened and imperfect contact exist at this point. Sh indicator show "discharge" with the lights turned off and at rest (providing that the indicator pointer is not bent), sulation on lamp wires may be injured, this permitting cont the frame, causing a short circuit. If the indicator i "charge" with the engine at rest, it is a positive indication pointer is bent.

If the charge indications are below normal with the engi ning, it may be on account of slipping of the driving bel dynamo is driven in that manner, or because of poor adjust the centrifugal governor, if that type of dynamo is used. ammeter "discharge" indications are above normal it is that the lamp load is excessive or one of the lamp wires is tact with the frame. When the indicator pointer jerks fr reading to another with engine running at constant speed discharge scale, it means either a short circuit in the syste loose terminal. If trouble is experienced from fuses burn repeatedly, it is a sign that the lamp wires are in contact v frame at some point or that one of the lamps is defective of a short circuited filament. If the engine cranking speed low and this is not due to the engine being stiff, such as w the case in cold weather or after the engine has been ove and bearings tightened, it may be considered a positive in that the storage battery is almost discharged or that it is d in some way. If the starting motor does not rotate; the may be discharged, the starting switch may not be maki contact or a motor brush may not make good contact with t

tator. There may be an open circuit in the battery wiring to motor, or there may be a poor circuit or contact because of corled battery terminals. If the starting motor rotates but does t crank the engine, it is a sign that the overrunning clutch does t work properly or that the starter pinion is not properly meshed th the flywheel gear.

If the lamps will not light but the starter cranks the engine, is shows that the storage battery is in proper condition and that trouble is due to burned out or broken lamp filament or detive lamp fuses. If the lamps burn brightly but fail to illumite the road sufficiently, the bulbs may be out of focus in respect the parabolic reflector of the lamp or the lamp supports may be nt in such a way that the rays of light may be directed too far wards. If the lamps burn dimly or not at all and it is difficult crank the engine with the starting motor, this means a weak or charged storage battery. In addition to this, the lamps may be l and have blackened insides, the system might be slightly short cuited, or considerable resistance may be present, due to loose or ty connections. If the lamps blacken or burn out quickly they not of the proper quality if they are six volt lamps, and not of proper voltage if other than six volt lamps. There is one exption to this rule, and that is the bulbs of the tail lamp and dash ht, which are three volt lamps when these two are wired together series. Burning out of the lamps may be caused by the regula- not working properly, and if this is the case the lamps will rn out at high engine speed. If the lamps flicker and the amter or indicator needle is unsteady, look for loose connections in light wires, loose connections between battery and dynamo, e contact at a lamp connector or lamp bulb, poor contact been fuses and fuse clips, or an exposed wire touching the frame ermittently.

If one suspects that the battery is discharged, its condition may readily determined by using the test lamp, shown at C, Fig. . The test lamp may also be used for locating short circuits pen circuits. It is well to bear in mind that the lead terminals he battery should be scraped clean and bright at the point where test lamp wires bear in order to insure a good clean contact.

If the test lamp burns brightly it shows that there is curren the storage battery. To locate a short circuit the fuses are moved from the rear of the switch and the wire is disconne from the negative battery terminal. Connect one of the test l terminals to the free battery terminal and touch the other test l wire to the frame of the car. The test lamp should light if g contact is made, this indicating that the positive battery termin properly connected to the ground. Keep one test lamp wir contact with the negative terminal and touch the other wire to end of the battery wire just disconnected. If the test lamp li it shows that a conductor or wire connected to the battery, la horn or starting motor is in contact with or grounded to the fr of the car.

Any wires having injured insulation should be wrapped electrical tape to prevent metallic contact between the condu and the frame. Open circuits are best indicated by feeling of wires where they fasten to the terminals to make sure that tive contact is made and that the terminal binding nuts are loose. Short circuits may also be located if no test lamp is a able by following the various wires and if any of these are foun contact with the frame, it is a wise precaution to pull them a and to wrap the section that was in contact with the frame t oughly with insulating tape. If one lamp flickers and the burn brightly, look for a poor connection between the lamp and lamp connector, a loose terminal at the junction switch or a d tive fuse. If all lamps flicker, look for loose connections in w between battery and junction switch. When lamp bulbs have renewed in head lights it is sometimes necessary to refocus lamps. Head lights should not exceed 15 candle power, and sh always be of the high efficiency filament type. Cheap carbon ment lamps will not only consume undue current but will not p enduring. Tungsten filament lamps are best.

Chalmers-Entz System.—This is used on the Chalmers M 26 and is shown at Fig. 310. It comprises a motor-generator, tery, switch and regulating device. The feature of the installa is that it prevents the gasoline engine from stalling, even whe car is in gear. For all normal driving the dash switch is left

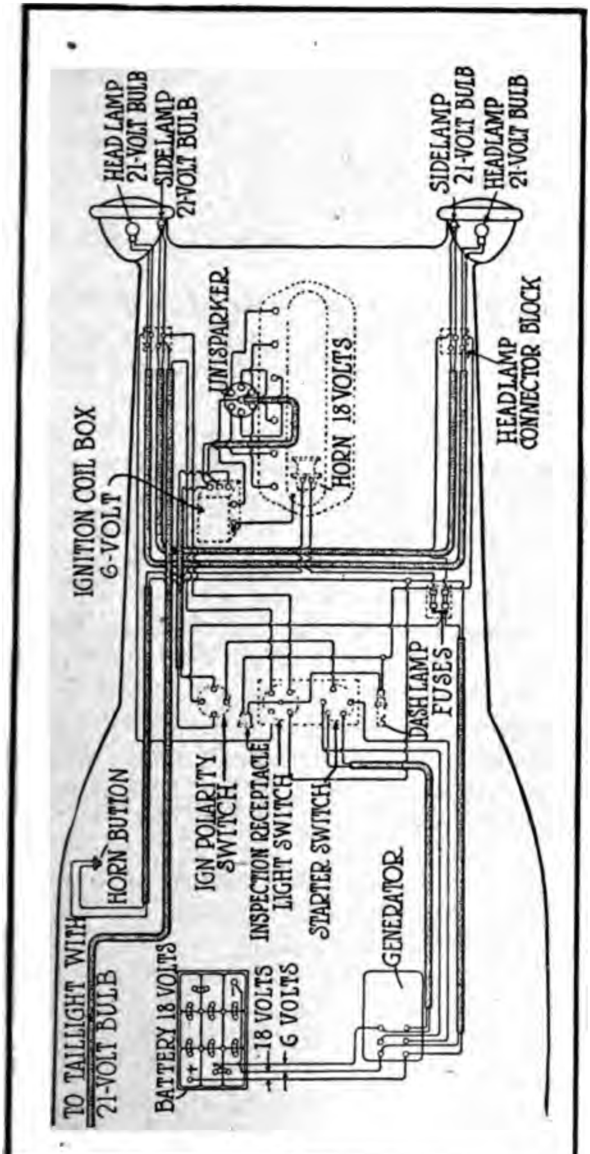


Fig. 310.—Wiring Diagram of Entz One Unit System.

position at the extreme right, or, in other words, the starting s
tem is constantly connected with the motor. For constant drivi
at speeds in excess of 30 miles an hour the dash switch should l
moved to the middle position in the slot. In this position the ig
tion of the motor is still operative, but the generative portion
the starting system is cut out so that the battery no longer is bei
charged. When there is a tendency for the engine to stop the ele
tric motor automatically picks up and turns the engine over unt
proper firing occurs.

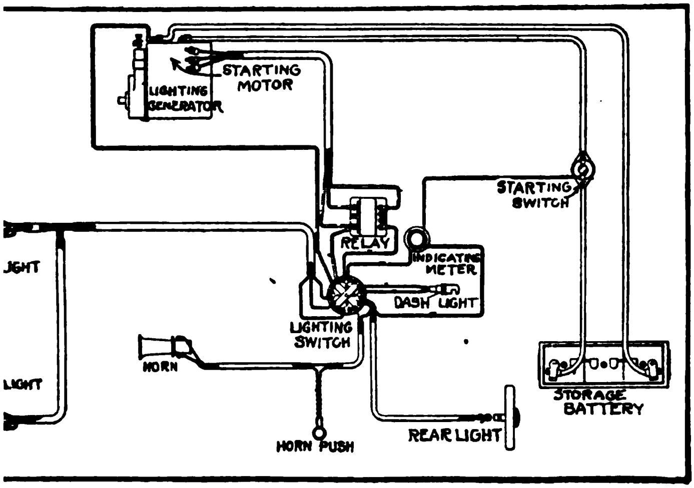
When the dash switch is thrown to the on position, current flo
from the battery to the motor-generator, which as a motor r
volves at about 100 r. p. m. As soon as the engine attains a spe
of approximately 600 r. p. m., 6 to 8 miles per hour, car spee
the direction of the current, due to the way the switch is connect
to fields and armature is reversed and the electrical machine th
becomes a generator, which in turn charges the storage batte
In the illustration, showing the wiring of the Entz system, the v
ages of the lamps are shown. In the case of the head lights,
small bulbs incorporated are also shown.

Remy Two-Armature Lighting and Starting System.—
electric starting motor and lighting generator on Series AA
tional cars is the Remy Model 150 six volt system. The elec
machine employs two separate armatures and two separate fie
the motor being superimposed upon the generator, although b
are in one steel casting, making a neat, compact unit, famili
dubbed a "double decker." The wiring diagram is shown
Fig. 311.

The two armatures are connected together by a train of g
and an overrunning clutch, so that the gears and motor arma
are in operation only when the starting switch is pressed. In
porating the reduction gearing and overrunning clutch of
starting-generator unit in an oil bath, insures silent operation
ing starting, as external gears and the meshing of the same
entirely eliminated.

The unit has only one drive shaft and is connected to th
gine by an Oldham coupling. This allows of quick and eas
moval from the engine for inspection if necessary, although

ɔn plates are provided on the unit itself, which is con-y and accessibly located on the engine. Although the frame two units is a steel casting, the magnetic circuits are en-ıdependent, as may be seen from the illustration. The ır is shunt wound and is automatically regulated for con-ırrent by a vibrator, which is mounted on the same base relay or electric cutout. The function of the regulator is the output of the generator constant regardless of the



.—**Wiring Diagram of the Remy-National Starting and Lighting System.**

the engine. The relay is simply an electric switch which ıd closes the circuit between the generator and battery auto-y to prevent dissipation of battery current in the generator e engine is at rest.

motor is of the conventional series type and is wound to ıd heavy overloads. Armatures, brush holders, fields, etc., ; in accordance with standard electrical practice. The gen-rindings are protected against injury by means of a fuse on the relay-regulator base. Should the battery become

disconnected either through accident or neglect, this fuse will bu thus protecting generator and field against excessive voltage, wh would result if the field circuit were not opened.

To start the engine the operator presses the starting swit which puts the motor armature into motion, engages the geari and clutch, and turns the engine over. When the engine is ru ning under its own power the clutch and engine are automatica disengaged and the unit operates only as a generator. The la load of the car is carried by the generator at about 12 miles p hour. As a "tell-tale" an indicator is employed, from which t operator may determine whether the generator is working pro erly. A simple lighting switch is used for turning on any combi tion of lamps. No side lamps are used, as the head lamps cont small independent bulbs for signal lamps. The two-wire system wiring is used. It has been carefully developed, resulting in a ve simple layout, as may be seen from the accompanying wiring pl of the system as applied to the six-cylinder National car.

Faults in Motors and Generators.—While every effort has be made by the manufacturers of electric starting and lighting s tems to have the various units function as nearly automatically possible, it will be evident that some attention will be needed the various units. The generator should be looked over from ti to time and should any carbon dust be worn from the brushes the commutator and deposited in the lower part of the casin should be blown out with compressed air. It is stated that an cumulation of this dust may result in a ground to the gener case or produce a short circuit between the brush carrier and c If the commutator is blackened or rough it must be smoothed do with fine sandpaper while the armature is rotating. Never emery cloth for this purpose. After smoothing down the com tator remove all particles of metal which may bridge across tween the copper segments. The insulating material between commutator segments should not be higher than the surface the segment, and if any of it projects it must be filed down slig lower than the copper pieces by using a small file.

The brushes are the part of the generator that demand the attention and to which most of the troubles in devices of this

e due. They should be examined to see that they are in perfect ntact with the commutator and that they do not stick in the ush holders. Any dirt or grease on the brush assembly should removed. One of the most fertile causes of poor brush contact th the commutator is on account of insufficient spring tension. hen examining the brushes care should be taken to see that these e maintained positively in contact with the copper segments. re should be taken not to have the spring pressure too great, as s would produce rapid depreciation of the brushes and heating the commutator. Brushes that have worn down till they are rt must be replaced with new ones. When replacing brushes sure that they fit the commutator surface exactly over the whole a of the end of the brush, and in all cases use brushes for re-cement furnished by the maker of the generator. In some gen-tors, shunt connections, which are called "pigtails," are used for necting the brushes. If the new brushes furnished by the fac-y have these connections attached care should be taken to make connection exactly the same as on the old brushes.

It is imperative that the commutator be kept clean, as any oil or ase on the segments will collect carbon dust and produce short uiting. The brush holders should be entirely insulated from carrying case, and if any of the insulating bushings, washers plates are found defective they must be replaced with new ones. uld the battery or generator be disconnected for any reason, not operate engine again until they are connected. Never run nerator unless connected to the battery. With the engine run-g and lamps burning, if the amperemeter hand stays at zero it cates that the generator is producing exactly the same amount current as the lamps are consuming. If the hand is on the dis-rge side of zero it means that the current-consuming units are ing more than the generator is producing. If the pointer is on charging side of the scale it shows that the generator is pro-ing more current than is being used by the lamps.

The starting motor is subject to the same electrical troubles as generator is. These are grounds, short circuits, brush and com-tator troubles. Defects in either the motor or generator drive f a purely mechanical nature and can be easily located by any

competent repairman. The centrifugal governor used on generators is not apt to give any trouble unless some of the fail or the action becomes clogged with oil and grease.] springs tending to return the weights are broken or become ened the generator will not deliver the proper amount of cı because the drive will not be positive. Any accumulation that will interfere with proper frictional adhesion betwee clutch parts where a governor is employed will also result iı ure to drive.

Faults in Wiring.—In the two wire system every wire nector and socket must be insulated from the car and shoul be in metallic contact at any point except at the terminal. imperative that all wires be insulated from each other and tl frame except at points where permanent connections are made connections should be soldered to insure positive contact aı curely wrapped with insulating tape. The wires must be securely by means of cleats of insulating material and mu mounted in such a way that there is no possibility of sharp corners or edges wearing through the insulation and ca grounds or short circuits.

All wiring should be protected from the rotting action of g oil and water, and when the wiring is run where these subst are apt to accumulate, the regular insulation should be su mented by a conduit of insulating material such as circular lo fiber tubing, or armored cable should be used. All wires shou so installed that there is no danger of interference between and operating rods and levers. The abrasion of these member wear through the insulation, and result in short circuits. Br copper terminal connections should be used at all points aı connection should be made by winding the strands of wire aı the terminal. One or more of the strands may bridge acro terminal or to some metal part and cause a short circuit or gr Special care should be taken with the connections in the lamp other points. By the term "short circuit" electricians mean two wires of opposite polarity are in metallic contact. Under conditions the storage battery will be discharging and there *be no lights* at the lamps. A short circuit may occur at any

the wiring system, but is usually found at terminals that have en carelessly made or by worn insulation on wires.

A short circuit will be indicated by the position of the ampere-ter pointer. Always note the position of the index hand of that trument when the car is stopped. With the engine at a stand-ll and no lamps burning the hand should point to zero. If it s not the amperemeter is either out of calibration or there is a k of current from the battery at some point in the wiring. To ertain if the amperemeter is correct, uncouple one of the battery minals of the lighting system. Obviously, if the hand swings to o, the trouble is leakage of current, which should be immediately rected after the trouble is located. If the index does not point zero when the battery terminal is disconnected, the instrument is of calibration, and while this does not affect the operation of system it should be taken into account when reading the am-remeter. If the engine backfires when the ignition is interrupted d it makes one or two revolutions in the reverse direction, the peremeter pointer may be found at the extreme of the scale on discharge side. This is caused by the circuit breaker contact ng held closed and means a short circuit of the battery through generator winding. This must be corrected at once by mo-ntarily disconnecting one of the generator wires or starting the ine. If the wires are removed from the generator for any rea-make sure that they are connected to the same terminals as y were originally. If the wires are reversed the amperemeter l indicate a dead short circuit by swinging to the extreme on discharge side of the scale when the engine is started, and if this ective condition is not corrected the battery will be soon dis-rged. In case of a short circuit examine all of the wires con-ted to the battery terminals and to the lighting switch. Make e that the insulation is perfect and that it has not been cut ough at any point. Whenever any wires are removed from any the units always mark the terminals and the wire so that they l be replaced exactly as they were originally. If a short circuit ts when all the switches are opened, if one takes off a battery minal and makes and breaks contact between the wire and that ber a small spark will be in evidence. If no sparking occurs,

connect up the terminal to the battery and then with the engi at a standstill close the switches to the lighting circuit one at time and watch the amperemeter closely as each switch makes co tact. If the pointer does not move far from zero it shows that t current consumption is normal; if, however, the pointer swings the extreme of the discharge scale it is evident that a short circ exists somewhere in the circuit just brought into action. All t circuits can be tried in this manner one at a time. If the ampe meter indicates only a normal amount of current consumption f the various lighting circuits it is apparent that no further sea is necessary. If, however, the needle indicates a short circuit one or more of the switch positions, examine the wires carefu for the circuits at fault, and if the trouble does not exist there may be located in the lamp socket, the connector or the bulb its In case one or more lamps fail to burn the trouble is due to eith a broken wire or a defective connection at the switch, connectors lamp sockets or a bulb or fuse is burnt out.

The following instructions relative to the care of the lamps a storage battery of the Auto-Lite system are taken from an instru tion book prepared by this company and apply to similar co ponents of all systems. Complete directions for the care and cha ing of storage batteries are given in the preceding chapter, but the same time a review of the important points to keep in mind connection with the maintenance of the batteries used in light and starting systems will prove of value to the motorist or rep man who does not desire to go thoroughly into the subject storage battery charging or maintenance.

To clean head and side lamp reflectors, remove from lamp b and carefully blow out any dust which may have collected on reflecting surfaces. Then dip a small piece of absorbent cotto alcohol and lightly wipe over the surface—always from the b to the front. To focus the lamps, open the swinging front of lamp and direct the light upon some smooth vertical surface distance of about ten feet. Loosen the adjusting screw on the at the rear of the reflector, and move the bulb and socket out in until all rings disappear in the illuminated area. Then tig down the adjusting screw and close the lamp. Any further ad

nt of the lamp must be made by bending the arms of the lamp acket with a heavy wrench until the light from each lamp strikes road at the point desired.

Do not connect additional apparatus, such as electrical horns, ar lighters, etc., to the system without taking the matter up with factory. The surplus capacity of the system is large, but there a limit to the amount of current which the generator can proce. Use the same judgment and reason in the operation of the ctric lights on a car as you do those in your home or garage. en a car is running it is not necessary to burn all the lights, the heads and the tail are all that are required or that are of any vice. When the car is standing at night, use the side and tail hts only. When push type connectors are used, if halves of contors are loose when pushed together, the contact will be poor. read the connector posts slightly so that they will slide in their kets snugly. If Ediswan type are used, and plunger springs in nector do not operate, replace the connector with a perfect one.

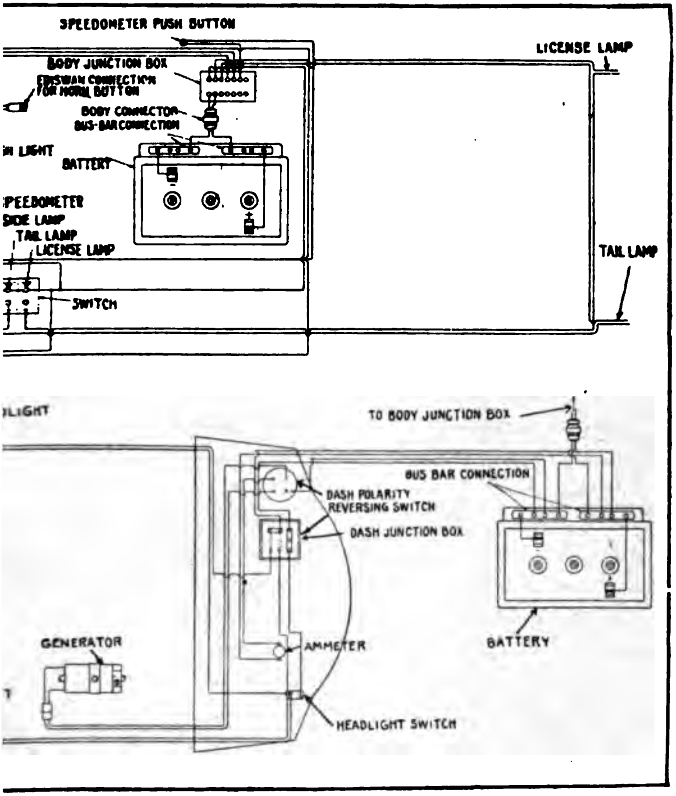
The storage battery is made up of several hard rubber cells or tainers for the active plates and liquid electrolyte. The whole urrounded by a wood casing for mechanical protection and ease andling. Each individual cell is provided with a screw cap inspection and the addition of electrolyte or distilled water a necessary. (See Fig. 301 and Fig. 305, B). The electrolyte t at all times cover the tops of the plates at least one-quarter . Insufficient electrolyte will result in warped or buckled es, and an accumulation of sediment at the bottom of the cells. battery will be ruined in a short time if the tops of the plates not kept covered. Each cell must be inspected at least once y week in summer and once every two weeks in winter. All w caps must be removed and distilled water added to each cell ake up for the natural evaporation. If distilled water cannot d use clean rain water which has not come in contact with l or cement.

ever add acid to the cells of the battery. If part or all of the rolyte has been lost through accidental spilling or leakage get nstructions and advice from the maker. An hydrometer, ar-l with a rubber bulb to draw a portion of the electrolyte

from each cell, furnishes the best indication of the conditi battery. The hydrometer shows the specific gravity of trolyte, which for a fully charged cell should be 1280 on gravity scale. If the car is out of service for a considerab of time, as when laid up for the winter, it is necessary t the battery at regular intervals. This may be done by rur engine at a car speed of twenty miles per hour for at hour every two weeks. If the car is to be stored, and it is venient to charge as above, the battery should be remov the car and placed in a reliable garage to be properly taker

If your battery is arranged with terminal posts for th connections these must be examined occasionally to see t are clean and free from sulphate. The thorough applicat small amount of vaseline at the metal connections to the posts will prevent sulphating and consequent corrosion a electrical contact at these points. If the electrolyte leaks joints, bottom, or wood sides of the battery case, one or the hard rubber cells are cracked or broken. The battery returned to the factory for repairs or replacement. The m tery box must be thoroughly wiped out with a cloth satura ammonia to neutralize the acid and prevent corrosion. of the battery must be kept clean and dry to prevent a le current between the terminals. See that the battery is curely in its metal box or other container. If necessa tightly with waste to prevent the battery shaking about fi ing of the car. Tools, other metal articles, or anything should not be placed near the battery as the acid fumes rode and destroy metal, cloth and like material. Make cert the battery terminals cannot touch the cover of the metal box. A thin sheet of wood fiber fitted inside the cover of tery box will prevent short circuits or grounds from th It must be remembered that the efficiency of any storage decreases with drop in temperature and it is only about 50 efficient at zero temperature. For this reason the demand rent should be kept as low as possible in cold weather an turned off when not needed.

The user of any electrical starting and lighting sys



312.—**Wiring Diagram, Showing Typical Lighting System.**

ıble and expense by the observation of the following ıs:

replace worn-out brushes with any others than those sup-he manufacturer.

put oil or grease on the commutator of the generator or o lubrication is wanted there.

turn the hose on the generator or motor when washing

tighten up on the silent chain drive unless the slack be-

comes excessive from stretching. The chain must be run wi reasonable amount of slack to prevent noise and wear.

Don't fail to lubricate the silent chain drive at frequent in vals. Noise will be eliminated and wear reduced. Keep the cl and sprockets clean, and free from dirt and gravel.

Don't run your car, if for any reason the battery is dis nected from the circuit, unless you have disconnected the ch driving the generator, or the generator itself has been removed.

Don't attempt to propel car with starter. Such "stunts" interesting, but expensive. Gasoline is for that purpose.

Don't attempt to make adjustments of any kind in the circ breaker.

Don't fuss with the system when it is operating properly.

Typical Lighting System.—In order to show clearly the w use that is made of electric current, even on cars not provided w an electric starting motor, wiring diagrams are shown at Fig. which represent the frame and body wiring of a Packard tour car without starting motor. This wiring is used solely for c veying battery current to the lamps and other current-consum units, which includes a Klaxon horn and speedometer light in dition to the usual lighting equipment of six lamps. Two r lamps are provided, one of these the usual red signal specified law, the other is a white light used to illuminate the license In order to make it possible to remove the body from the ch without destroying the wiring, the current conductors are ru two independent groups, one being secured to the body, the o running through suitable conduits attached to the frame. upper view shows the body wiring with the storage battery nected, though this member is carried by the frame and h connector which may be readily broken when desired to join battery with the body junction box. Among the appliances ried by the body may be mentioned the side lamps, the speedo and dash lights; the Klaxon horn, and the two tail lamps. arrangement of the wiring is clearly shown in the illustration, method of running the wires from the junction box to the va units is clearly defined. Attached to the chassis are the two *lights,* the storage battery, and the lighting generator. In

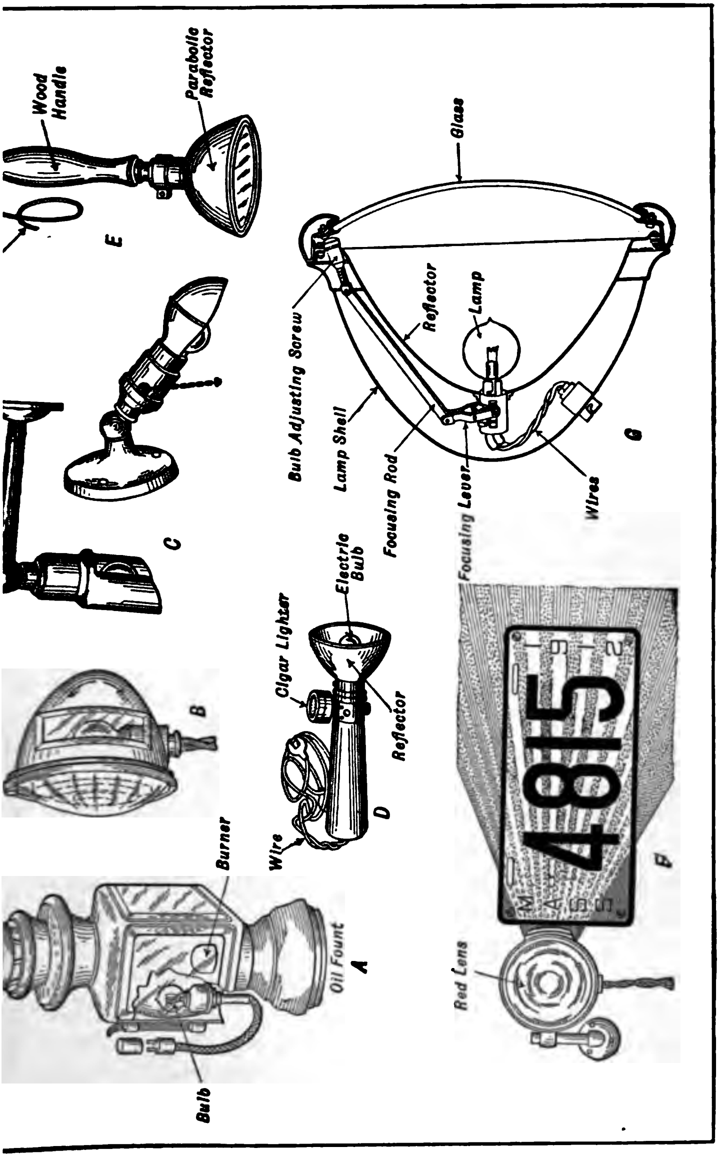


Fig. 313.—Group of Lamps Used in Connection with Electric Lighting System.

system the generator is used to charge the storage battery, the cu rent going through the usual automatic cutout switch to preven a reversal of current at such times that the generator is not sup plying enough energy to charge the battery. As is true of the dia gram presented above, all of the circuits are clearly shown and ma be readily followed by any one.

The construction of the various forms of electric lamps used i motor car lighting systems is clearly shown in Fig. 313. Th lamp outlined at A is a combination form, designed to use eith kerosene or electricity, the former being used only in the event o failure of the latter. The side lamp at B is a neat form, intend to use electricity only. Dash, coil and speedometer lamps are de picted at C. A combination trouble lamp and cigar lighter i shown at D. The trouble lamp at E is an easily portable fo and is convenient for use around the power plant, gasoline ta etc., deriving its current from the regular battery. A combinati tail lamp, having red lens at the rear and a white glass at t side to illuminate the number plate, is shown at F. The appro construction of a variable focus electric head lamp is shown at

CHAPTER VII

CLUTCH AND GEARBOX FAULTS

Principal Clutch Troubles Outlined—Cone Clutch Construction and Adju ment—Cone Clutch Repair—Plate and Disc Clutches—Band Clutche Planetary Gearset Repair—Friction Drive Faults and Remedie Troubles in Sliding Gear Transmission.

IT is not difficult to locate defects in the power plant, as t symptoms resulting from faulty action of the engine mechani and the parts of the auxiliary groups are such that can be read recognized by comparatively inexperienced repairmen. There a a number of points in the power transmission system that may (preciate in service and their faulty action will not be immediat discovered. There may be serious wear in the power transm sion elements, such as the gear box and the rear axle, which w mean a serious diminution in the amount of power delivered the rear wheels. As these faults are usually of a purely mech ical nature, they are not generally known, and as a rule only sh up in a positive manner when a car is overhauled thoroughly.

Principal Clutch Troubles Outlined.—The first member of t power transmission system to be considered is the friction clut in its various forms, and it is important that clutch troubles readily recognized, as the power, capacity and speed of the ent vehicle will be affected if the clutch action is not as it should l Considering first the general troubles which are apt to materi ize with all types of clutches, we will consider as the most importa a too sudden or harsh engagement, which causes "grabbing," fa ure to transmit the entire engine power, lack of capacity due failure to engage properly and poor or slow release, which resu in "spinning." Clutches that employ frictional material as facing will not act properly if the material becomes worn or

is glazed over. Besides the trouble due to defective friction members, there are other portions of the clutch mechanism that demand care and inspection. As the cone clutch is the most common, we will describe the construction of a typical clutch of this nature and then consider the methods of repairing defects that may materialize in service.

Cone Clutch Construction and Adjustment.—The cone clutch assembly shown at Fig. 314 is that used on National automobiles and is one that has given excellent service. The female member is machined in the flywheel rim while the male member, from which the clutch type takes its name, is a truncated cone or saucer-shaped

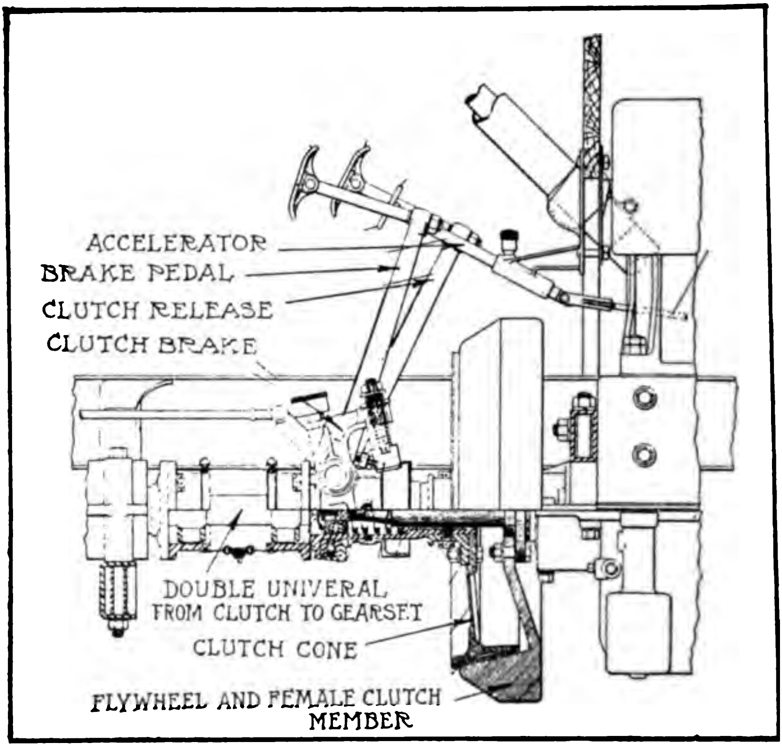


Fig. 314.—Clutch and Control Pedal Assembly of National Automobile

mber cast of aluminum, which has a friction facing of leather. e clutch cone transmits power by virtue of frictional adhesion :h the flywheel rim, this amount of friction being increased by : wedging action due to the angular face of the clutch members. e pressure maintaining the parts in engagement is produced by

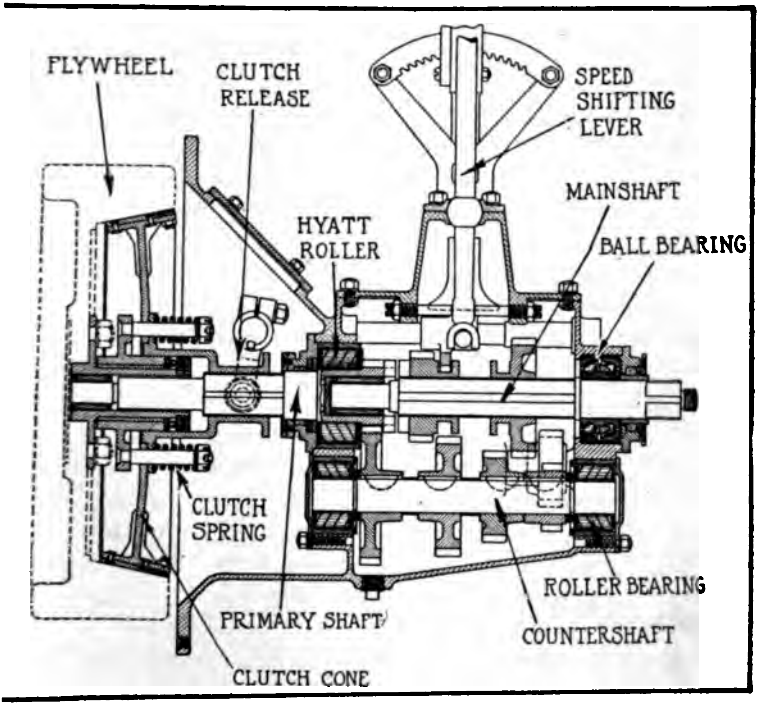


Fig. 315.—Sectional View, Showing Gear Box and Clutch Assembly, Forming Part of Unit Power Plant.

ubstantial coil spring carried by the flywheel extension, this ing exerting its pressure against the cone-carrying member having its reaction absorbed by an anti-friction bearing of the form. The power from the clutch cone carrier is transmitted ı double universal joint to the gearbox, placed back of the clutch about midway on the chassis frame.

The views of the National chassis presented at Fig. 339 will show the relation of the clutch and gear box in the National car very clearly. When it is desired to interrupt the engine drive the clutch release pedal is depressed, this pulling the clutch cone carrier so the cone is pulled away from the female clutch member. In order to prevent "spinning" and make gear shifting easy, as soon as the clutch cone is fully released a friction brake interlocked with the clutch pedal is brought in contact with a small brake drum member, which retards clutch movement. Another form of friction clutch, showing its relation to the gearbox of a unit power plant, is clearly outlined at Fig. 315. This is of Covert manufacture and will be found on a number of 1915 automobiles. When the clutch and gearset are incorporated as a unit the design of the engine is such that the gear box is bolted directly to the engine crankcase in order to obtain a unit power plant. In this cone clutch the spring pressure maintaining contact between the male and female clutch members is produced by four coil springs carried outside of the clutch cone, where they may be easily reached through the clutch case cover when it is necessary to increase their tension.

It will be apparent that as the clutch facing wears and the cone seats itself deeper into the female member that the spring tension may be reduced to some extent. In the clutch shown the spring pressure may be increased as desired by pulling out the split pins that keep the castellated adjusting nuts from turning and screwing each of these members in the same amount, endeavor being made to have the tension of all springs as nearly equal as possible. The clutch springs exert their pressure against the clutch cone at one end and the reaction is taken through the stud to a spider member between the clutch cone and the flywheel, which bears against a ball thrust-bearing carried by the crankshaft extension member bolted to the flywheel, as indicated. When it is desired to release the clutch, the pedal rocks a shaft to which a yoke member is fastened. This yoke member carries rolls which bear against an upturned flange on the clutch cone carrier, which also transmits the power of the engine to the squared end of the primary shaft. The *construction* of the gear box will be described in proper sequence.

The clutch shown at Fig. 316, A, is used on models B-2A ar

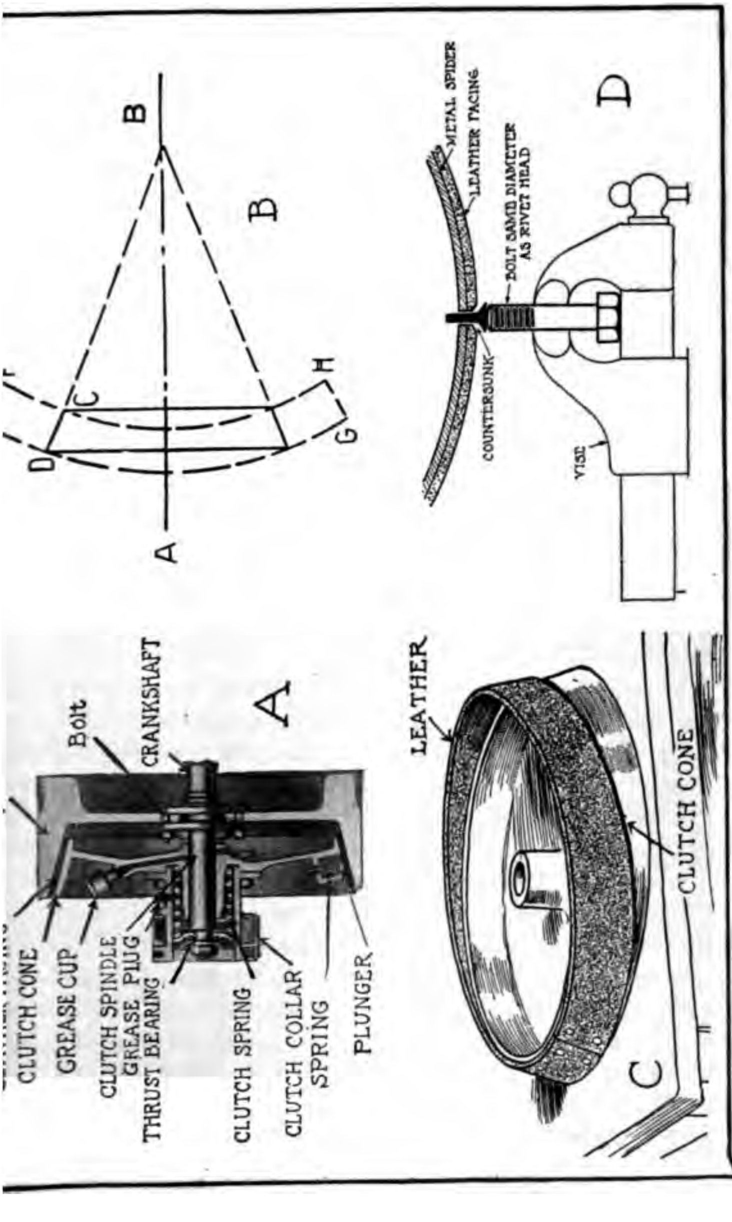


Fig. 316.—Processes Incidental to Refacing Clutch Cone Outlined.

B-25 Buick cars. It is of the leather-faced cone type, having three plungers pressed against a leather facing by coil springs to make for easy engagement. The construction is clearly shown in the accompanying sectional view, which also points out the portions needing lubrication. Of these, the clutch spindle is lubricated by a grease cup carried by the clutch cone, while a pipe plug is placed in the spring housing to introduce grease for the thrust bearing. In this clutch the spring tension may be increased by screwing in the threaded nut on the end of the crankshaft extension. The clutch cone is of aluminum and is tapered in the usual way, having a standard angle of 12½ degrees. The cone is held in engagement with the flywheel by the large coil spring enclosed in a housing member, that also serves as a clutch cone carrier. At the rear of this sleeve or housing member is placed the coupling which connects the clutch with the primary shaft of the change speed gearing. The housing carries a collar connected with the clutch pedal, so that when that member is depressed the clutch spring is compressed and the cone pulled away from the flywheel rim. After the clutch has overcome the inertia imparted by the flywheel it remains stationary when released, the crankshaft extension rotating freely inside of the clutch spindle bearing.

The most common cause of faulty clutch action is some defect of the leather facing, as this may be packed down hard or charred by heat from slipping, or it may have been used so long that the leather has lost its life and become hard, with a glazed surface that has a very low degree of frictional adhesion. The clutch spring may have become weakened or broken; this will cause the clutch to slip, even if the leather facing is in good condition. The two troubles usually met with are harsh action as one extreme condition and power loss because of slipping as the other. If the surface of the leather lining becomes hard and does not have enough resiliency to yield slightly when first brought into frictional contact with a flywheel rim, this results in harsh engagement. To insure gradual clutch application the friction lining should be soft and elastic. If the leather has not been charred or is not worn too much it may often be softened by rubbing it with neatsfoot oil and allowing hat substance to soak into the pores of the leather. Kerosene o

is often enough to keep the clutch leather soft and pliable, and i has an added advantage in that it has so little lubricating valu that the clutch members are not likely to slip because of reduce friction. Kerosene also has a quick penetration property that i valuable and does not collect grit or gum. Cylinder or machine oi should never be used to soften a clutch leather.

When a cone clutch slips and the friction facing is not wor or the spring tension is not lessened the trouble is usually due t a coating of lubricating oil on the frictional material, that reduce the friction so that the pressure of the clutch spring is not grea enough to keep the clutch parts tightly pressed together in posi tive driving engagement. A simple remedy for this defective con dition is to absorb the surplus lubricant by rubbing a small quan tity of Fuller's earth into the leather surface. When a clutch con is assembled it is not easy to reach the friction lining. The firs step is to disengage or release the clutch and fasten the releasin mechanism in such a way that the clutch cone will stay out of en gagement even when the pressure is released on the pedal. O some cars the clutch release and emergency brake applying me chanism are interlocked so that applying the hand lever will releas the clutch. The clutch may be held out of engagement in this cas by latching the emergency brake lever. The Fuller's earth i placed on a piece of paper or card so it can be sprinkled into th space left between the male and female members. Powdered bora is often recommended for the same purpose. Rosin is sometime advised, but this material should not be placed between the clutc members, as if there is any tendency to slipping and any genera tion of heat it may be melted and will become a lubricant that wil intensify the slipping instead of acting to absorb the oil, as th Fuller's earth or borax will.

If slipping is caused by a broken clutch spring, which is a ver rare occurrence, or by weakening of the clutch spring, which i more common, the method of repair is evident, this consisting o substituting springs of proper strength where no adjustment i provided or by increasing the degree of compression of the weak spring if some method of compensation for shortening the sprin is provided. Another annoying condition when a cone or th

plate clutch is used or where the clutch-driven members are of lar[ge] diameter and have considerable weight, is "spinning" or conti[nu]ual rotation of the male clutch member when the spring pressure i[s] released. This is often due to inertia, but is sometimes caused b[y] a defect in the clutch mechanism. If the bearing on which the con[e] revolves when disengaged is not properly lubricated or if a poo[r] grade of grease is used for this purpose the bearing may stick and the male clutch member will continue to rotate, even when the spring pressure is released. The ball thrust bearing employed to take clutch spring reaction, and which is clearly shown in the various sectional views previously described and in Fig. 318, which shows a cone clutch partially dismantled, may become wedged by a broken ball or particles of foreign matter, and if rotation of the parts relative to each other is prevented the rotation of the crankshaft will be imparted to the cone member through the clutch spring, which must turn with the crankshaft instead of remaining stationary, as would be the case if the ball thrust bearing were functioning as it should.

A seized clutch spindle bearing can only be repaired by taking the clutch apart and dressing down the scored journal, supplying a new bushing and removing the cause of the seizure. Sometimes when the clutch cone is carried on plain bearings wear in these members will permit the cone to sag because of its weight, and even though the spring pressure is fully released the lower portion of the cone will come in contact with the flywheel and the cone will be kept in rotation. Faulty clutch action is often traced to points distinct from the clutch mechanism itself. This applies to all types of clutches. Many cases of failure of clutch to release have been found due to imperfect relation of interlocking levers or rods or depreciation in some mechanical parts. If the clutch shifting collar is worn unduly or the small pins in the rod yokes connecting the clutch pedal with the release mechanism have worn, the pedal may be fully depressed and yet the pressure of the spring keeping the parts in contact may not be reduced to any extent. Where the emergency brake lever is interlocked with the clutch release leverage it may be possible that an adjustment of the brake rod, if *these* are shortened to compensate for wear of the brakes, w

change the length and may throw out the clutch mechanism slight and cause slipping of the clutch because the spring pressure m be partially relieved.

The clutch release mechanism used on the Overland car as w as the provisions for adjusting the clutch spring are clearly sho at Fig. 319. When the clutch cone facing wears the only reme is to dismantle the clutch, as shown at Fig. 318, which permits o to remove the old clutch lining from the cone and rivet a new o

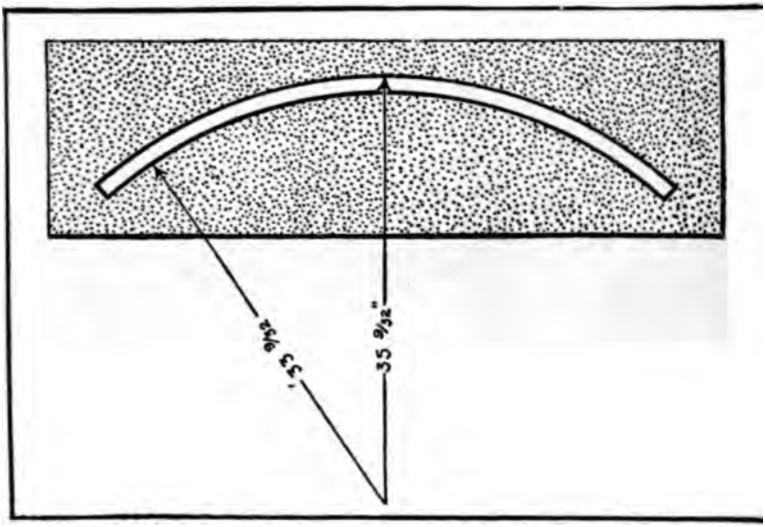


Fig. 317.—Pattern for Cutting Clutch Leather for Overland Model 8 and 81 Cars.

in its place. If the old facing can be removed without breaking, may be employed as a pattern or basis for a new lining. If t car is a model of standard make and recent manufacture the b plan is to obtain a new clutch facing from the manufacturer. Ho ever if the car is an old model or if the facing must be put immediately it is not difficult to lay out a clutch leather that w go in place *without difficulty.*

The first step is to lay out the clutch to exact size on b

drawing paper, making sure that the faces are at the proper an This may be done as shown at Fig. 316, B. Draw a long l through the center of the clutch cone and parallel with the hu this being represented by the line AB in the drawing. Contin the angle of the cone by straight lines, meeting at a point in t center line. Using this point as a center and the distance from to C and B to D as radii, describe the arcs of circles EG and F The distance from E to G must equal the larger circumference

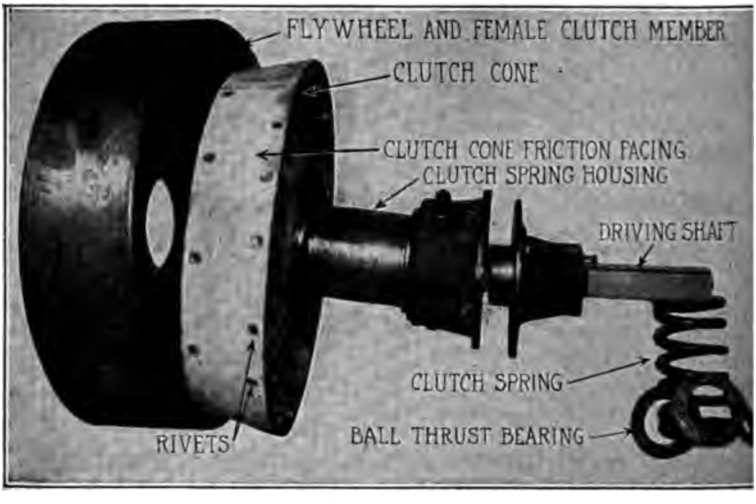


Fig. 318.—Cone Clutch Partially Disassembled to Show Important Components.

the cone so the ends will butt together, or it may be advisable make the strip somewhat longer than necessary to allow for fittin The pattern thus obtained may be used to cut the new leather. special friction leather which is made for this purpose should used. The thickness of the facing is important, because if it too thick it will prevent the cone from entering the flywheel as should. The clutch leather is usually one-quarter inch thick.

Before riveting the leather in place it should be made as plial as possible with neatsfoot or castor oil, though all repairmen are in agreement regarding this practice. Some advocate soaking t

leather in water and applying to the cone wet so that when dries it will shrink and hug the cone closer. Others apply it d and oil it after it is placed. In the opinion of the writer, which is based on considerable experience, letting the leather shrink is likely to result in the friction facing pulling away from the rivets, while oiling the material after application is apt to cause expansion and an uneven surface. When the leather is oiled before application it is soft and pliable and there will be no trouble in the material becoming loose from its fastenings if it is properly fitted. There are two methods of fitting the clutch leather. One of these is to attach the leather at one e holding it on the cone with a machinist's clamp or hand vise, wh the holes are then drilled in the leather to coincide with those the cone. The two holes at the extreme end are first drilled a the leather riveted in place, care being taken that the holes for t rivet heads are countersunk deep enough so the copper will be w below the surface of the leather. After the end is securely fasten the leather is pulled tightly around the cone to the next point fastening, the facing again being retained by clamps while the ho are drilled and the rivets applied. This operation is repeated fr one point of attachment to the next. This method insures that facing will hug the cone closely instead of standing away fro

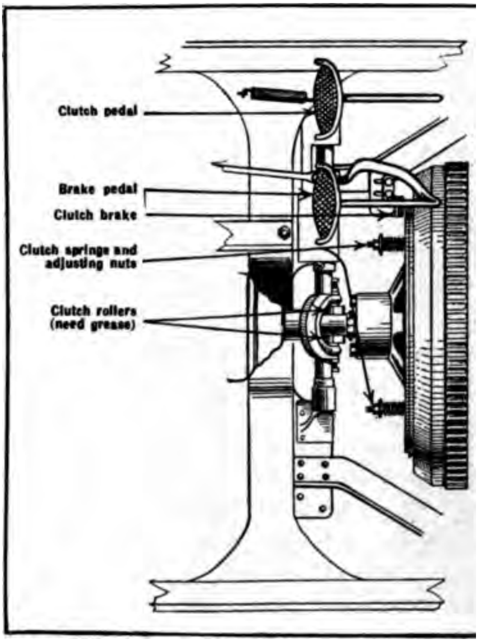


Fig. 319.—Clutch Control Assembly of Overland Automobiles.

tween the rivets, as is sometimes the case when all holes are drilled in the leather before application, which is the alternative method.

After a facing is applied it should be trued in a lathe by taking a light cut off its surface or the high spots may be rubbed off by hand with sandpaper, a piece of glass or a coarse file until a a full bearing is obtained all over the clutch facing. The material ordinarily used is good oak bark tanned belting leather, though hemlock and chrome tanned leather have been used with good results. The oak tan seems to possess all the desired qualities of elasticity, durability and degree of frictional adhesion required. The other method of applying the leather is to rivet the two ends to the cone as shown at Fig. 316, C, and then to pull the leather in place and rivet at the point directly opposite that where the two ends are riveted. The other rivet holes are then drilled to correspond with those in the cone. It is not desirable to cut woven wire asbestos fabric, and when this material is used it must be obtained all ready woven to form from the car manufacturer. Special copper rivets are used for riveting the friction facing to the cone. These have broad, flat heads of medium thickness, in order that they will keep the leather firmly in place without danger of pulling through, as would be the case if the rivet heads were small. Care should be taken to countersink deep enough for the rivet heads so that these will not touch the female member until the leather is worn so much that it needs renewing.

It is not difficult to do a good job of riveting if a bolt or punch the same diameter as the rivet head is used as a support, as shown at Fig. 316, D, and the end of the rivet is burred over with a rivet set, or with the ball pein end of a machinist's hammer. The punch supports the head of the rivet and forces it positively into the countersunk hole and insures a good tight fit. On some clutch cones, notably that used in models of the White automobile the friction facing is held on the cone by means of T-bolts, which fit into depressions cast into the cone spider. Renewal of the leather is a simple matter, as the worn facing may be removed by loosening the clamping members and a new facing easily applied. The method of making a pattern for the clutch leather on some of the Overland car models is clearly shown at Fig. 31[illegible]

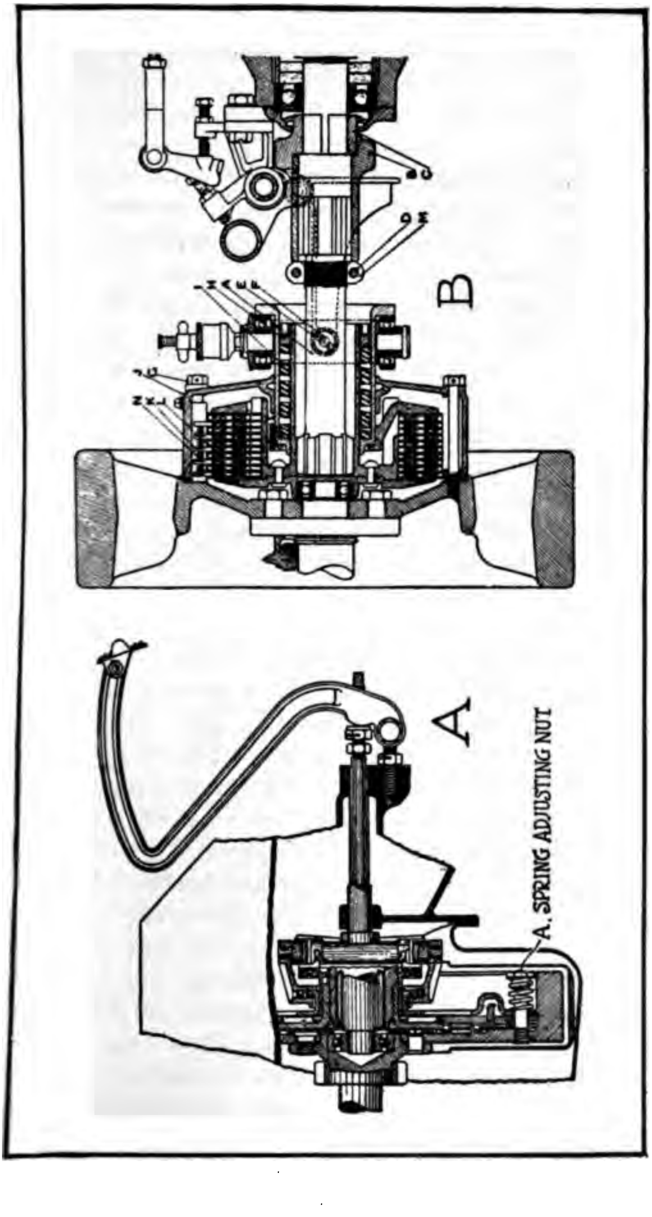


Fig. 320.—Showing Clutch Construction of 1914 Hupmobile at A and Multiple Disc Clutch Used on Premier Automobile at B.

It will be observed that the radius for the inner circle is 33[illegible] inches, while that for the outer arc is $35\frac{9}{32}$ inches. The lengt should correspond to the circumference of the clutch cone, o $44\frac{3}{16}$ inches. The rough or flesh side of the leather is place outside.

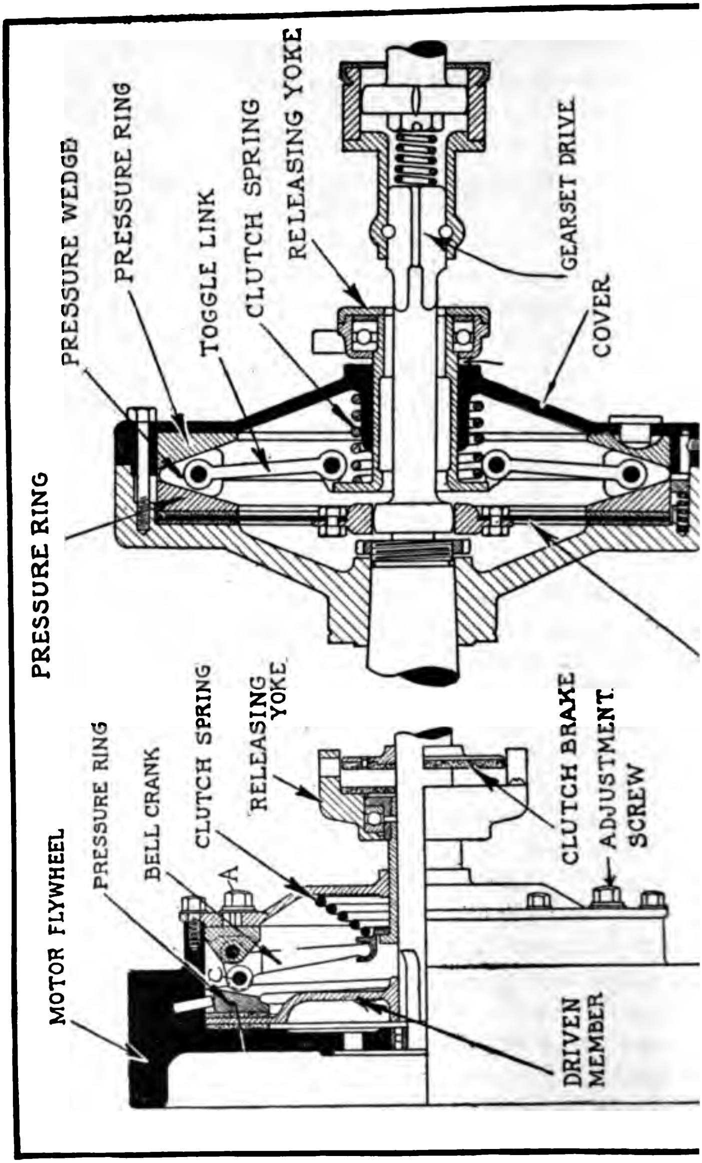
Plate and Disc Clutches.—Multiple disc or three plate clutch are subjected to practically the same main troubles as found i the cone type, i.e., they will engage harshly or fail to transmit th engine power in a positive manner. If a multiple disc clutch of th all-metal plate type does not release properly, it is because th surfaces of the plates have become rough and tend to adhere to-gether. The plates should be smooth and free from any roug particles or score marks, as these will always produce harsh en-gagement. This condition also results if there is insufficient o or unsuitable lubricant in those types where the discs are designe to run in an oil bath. "Spinning" or continuous rotation of multiple disc assembly often results from seizing due to gummed oil the presence of carbon or burnt oil between the plates, and in so cases by a lack of oil between the members. When an all-met multiple disc clutch slips, this generally results because of reduce strength in the clutch springs, distortion of the plates, or the u of too heavy lubricating oil. To secure the best results from multiple disc clutch it is imperative that only certain grades oil be used. If one uses a cheap or inferior lubricant it will car-bonize because of the heat present when the plates slip, or it wi gum up owing to the admixture of animal fats or other adu-lterants.

In a number of cases faulty multiple disc clutch action is du to "brooming," which is a name given for a defective conditi that exists when the sides of the kyeway have become indent and prevent free movements of the plates, or when the plate edg become burred over and prevent full contact of the plates. I most cases the adjustment of a multiple disc clutch is easily a complished by adjusting nuts that may be easily reached if t clutch is of the dry plate type, as shown at Fig. 320, A, which a representation of the 1914 Hupmobile clutch. The adjusting n *is indicated* and there are a number of these carried around th

'y of the flywheel. Whenever the dry plate clutch is used, of the series of discs is faced with some friction material, Raybestos, and, of course, when this facing wears it must .ced with new just the same as advised for the cone clutch. ıcings are usually of asbestos fabric, and must be procured in the special ring form of suitable dimensions for that make of clutch. It is not possible for the repairman or t to cut his own plate facing, as the material is hard to and there would be much waste if attemot was made to . segments from a wide strip of material.

ypical multiple plate clutch of approved design is shown 320, B. This is used on the series X Premier car. It is l to operate in oil and is housed in a dust-proof casing l to the rear of the fan-blade-spoked flywheel. Connec- ;ween the clutch and gearset is by means of a hardened shaft A, broached at its forward end to engage with the and having at the rear a joint coupling B, which engages similar part C on the gearbox. The sleeve B, which carries pling slides upon the clutch shaft may be easily moved by removing the clamping collar D. This is split so that be easily removed from the threaded portion. In remov- clutch the first operation is to displace the floor board r to gain access to the clutch casing. Remove the cotter from the pins F in the pedal shaft end of the cradle. the split nut D from the clutch shaft A and slip the 3 forward, in order to release it from the coupling C. move the eight retaining screws G in the clutch cover on 'heel, which will permit of removing the clutch and drive To take the clutch apart back off the clutch nut H, which ease the clutch spring and enable that member to be lifted he spring nut H is not used for making adjustment, as necessary. A spanner wrench or two quarter-inch pins connection with a bar may be employed for backing off ch nut H. The clutch cover J can be easily removed by ut the spring, and the small and large plates L and K will l on the clutch plate holder.

e plates should be taken off and thoroughly cleaned. If


PRESSURE RING
PRESSURE WEDGE
PRESSURE RING
TOGGLE LINK
CLUTCH SPRING
RELEASING YOKE
GEARSET DRIVE
COVER
MOTOR FLYWHEEL
PRESSURE RING
BELL CRANK
CLUTCH SPRING
RELEASING YOKE
A
C
CLUTCH BRAKE
ADJUSTMENT SCREW
DRIVEN MEMBER

iderable depreciation is noted, new ones should be substituted the worn members. The small plates L have lugs upon their r edges which engage in the keyways or grooves cut on the of the spider. The large plates K have a series of lugs on r outer edges to fit into the grooves in the clutch cover. In sembling this clutch it is important that the lugs of the large are so arranged as to fit alternate slots, thereby providing e between every other plate for the placing of the small ings which must be assembled so as to project toward the rear he car. The last two springs are arranged to touch the inside the clutch cover. The object of these small springs N is to e the clutch plates K apart when the clutch pedal is released. Before replacing the clutch cover, coat the edges with shellac nsure an oil-tight fit. Slide the clutch shaft A forward into clutch until it strikes the bottom of its socket. Slide the sleeve with the three joint coupling back until it engages with the ting member on the transmission primary shaft. Replace the t nut D, screwing it along the shaft until both the shaft and sleeve are forced securely into place, then screw the nut forward ut .03 inch to allow that much end play in the clutch shaft, l tighten the two screws securely. The makers of the Premier tch recommend lubricating the clutch every five hundred miles. s is accomplished by removing the filler plug and using a funnel replenish the supply. If the clutch is suspected of chattering harsh engagement, the first step is to make sure that all the or cylinders are firing regularly and that it is the clutch t is at fault. If the clutch drags or does not release promptly, ct about a pint of kerosene, running the motor a few minutes h the clutch disengaged and with the gears engaged in the neet. This holds the clutch spider or disc carrier stationary, reas the other set of discs, which is carried by the clutch case, lves and washes the kerosene thoroughly between all the plates. nove the kerosene after this operation is completed and refill the ch case with new, clean oil. The clutch operating linkage should ubricated every day and the grease cups just to the rear of clutch housing should be turned down frequently.

Examples of the three plate clutch construction in which a

single large driven member is used, faced with rings of fricti
material, are shown at Fig. 321. That at the left is the Hay
clutch, the spring pressure being multiplied by a bell crank wh
presses the clutch pressure ring against the driven member a
brings that to bear against a suitably machined face on the f
wheel web. The driven member is carried by and rotates w
the shaft used to transmit the power of the clutch to the gear
It is possible to compensate for wear of the friction faces
screwing in on the adjustment screws A which push the ring me
ber carrying the bell cranks closer to the pressure ring. Owi
to the large size of the driven member this type of clutch w
continue to rotate after the clutch spring pressure is relea
unless a clutch brake is provided. This is a very simple co
struction consisting of a plate attached to and turning with t
shaft supporting the driven member and a friction pad carri
by the releasing yoke. The general construction of the clutch
so clearly shown that further description seems unnecessary.

Another form of three plate clutch which is used on so
models of the White automobile is shown at the right of Fig. 3
In this the driven plate is clamped between the flywheel face a
the pressure ring by a force exerted against a pressure wedge
the toggle links which are pressed outward by the usual form
coil spring. When it is desired to interrupt the drive the rel
ing yoke is moved so that the clutch spring is compressed and t
toggle links pull the pressure wedges from between the incli
faces of the pressure ring. A variety of multiple disc clutches
shown at Fig. 322, all of these operating on practically the sa
general principles. That shown at A' is used on the Chand
automobile. That at B is an all metal disc assembly of Fran
design. The King clutch is shown at C, this having a series
adjusting nuts AAA, which may be used to augment the clu
spring pressure if the clutch shows any signs of slipping. T
clutch used on the Hudson cars is shown at D. This also emp
a series of small springs having adjusting means instead of
large coil spring not provided with any compensation for los
strength. The clutches shown at A, C and B have plain metal d
alternating with heavier plates provided with cork inserts.

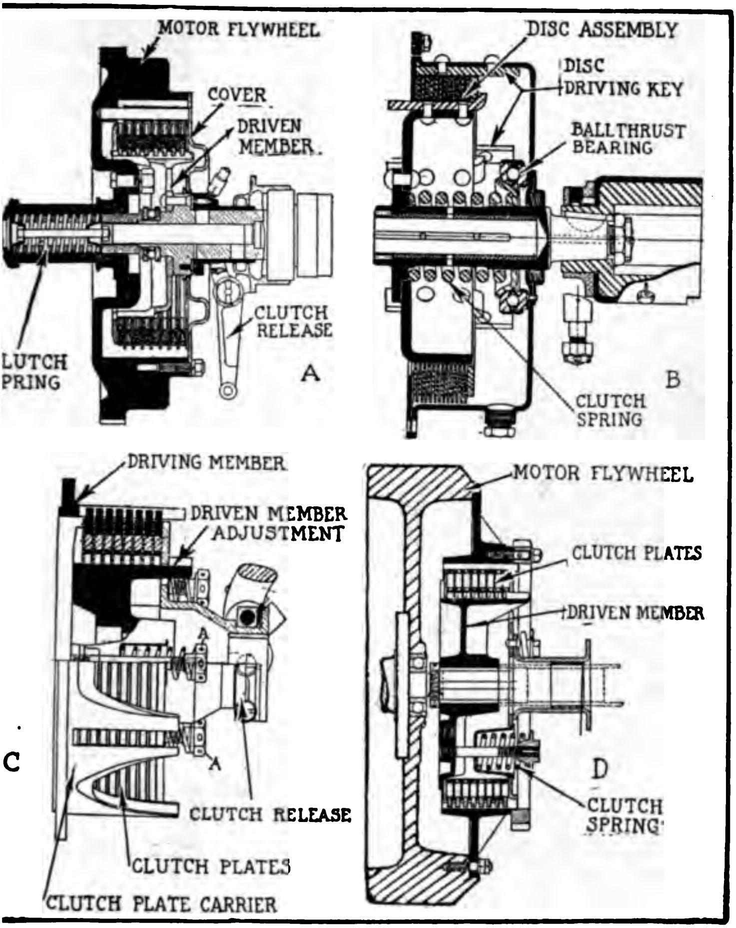


Fig. 322.—Group Showing Multiple-Plate Clutches Used on Modern Automobiles.

e instructions previously given in connection with the other tiple disc clutches apply to these forms as well.

The relation of a multiple plate clutch to the complete power it and *gear box assembly* is clearly shown at Fig. 324. The *iple dry plate clutch* shown detached from the gearset unit

sembly. A plan view of the gear

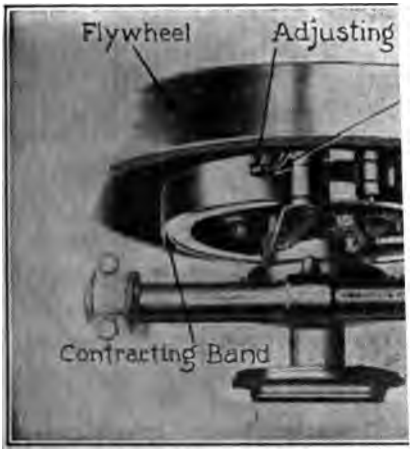
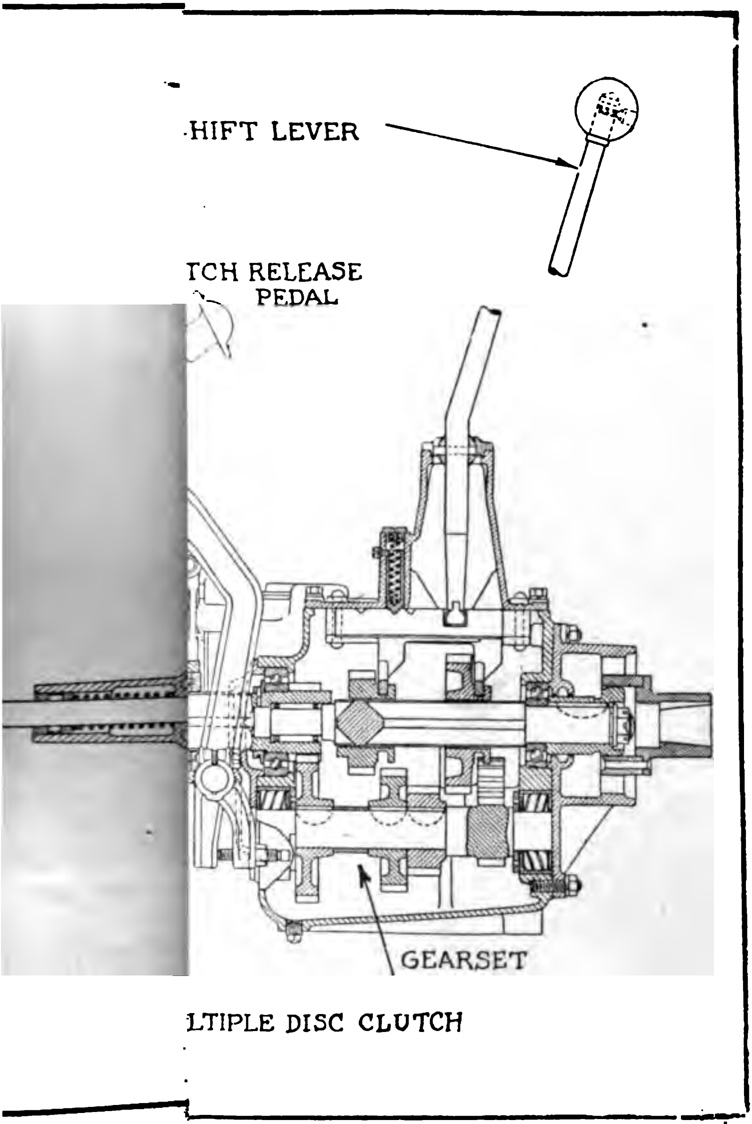


Fig. 323.—External Constricting I

and showing the mainshaft and th
in this illustration.

Band Clutches.—Band clutche
extent in automobile



nerating Unit.

or soaked with oil it was much more apt to slip than a cone ı, so as soon as the leather facing had worn slightly and the tment had reached its limit, it was necessary to reface the This was done in the same manner as advised for replace- of worn cone clutch frictions, though more care is needed in g off the face of the leather.

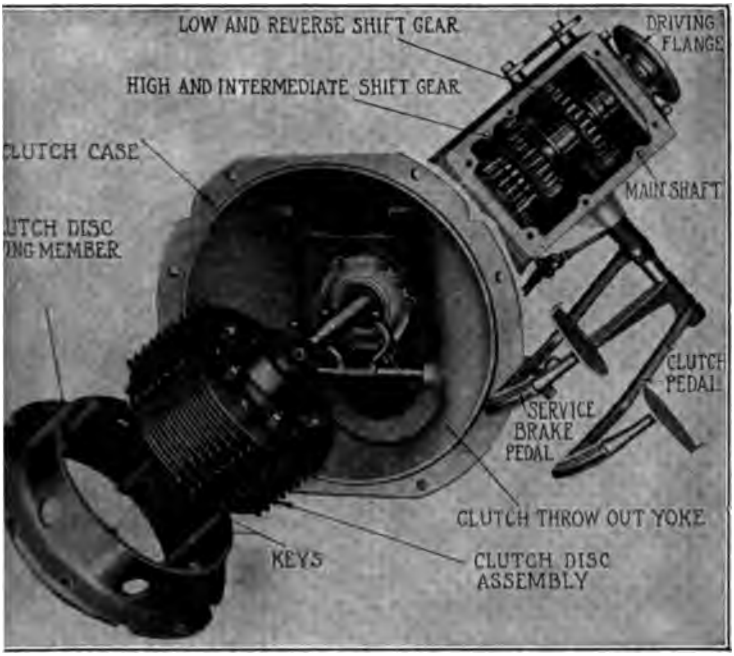
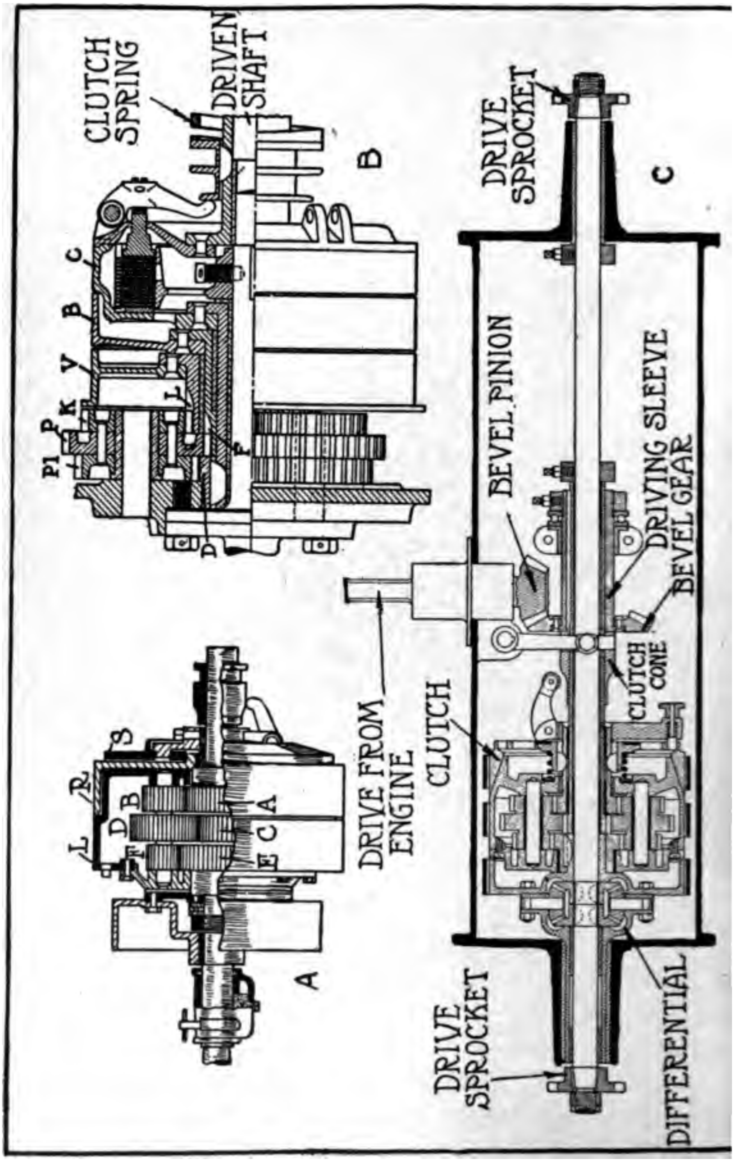


Fig. 325.—Clutch and Gearset of 1915 Cadillac Automobile.

ı external contracting band clutch which was used on a num- f models of the Haynes cars is shown at Fig. 323. In this tracting band is tightened around a steel drum attached to ywheel by a simple leverage, as indicated. An adjusting was provided for compensating for wear of the clutch band. ler to adjust the band the locking nut was unscrewed and ljusting screw set to obtain the required amount of friction contact.

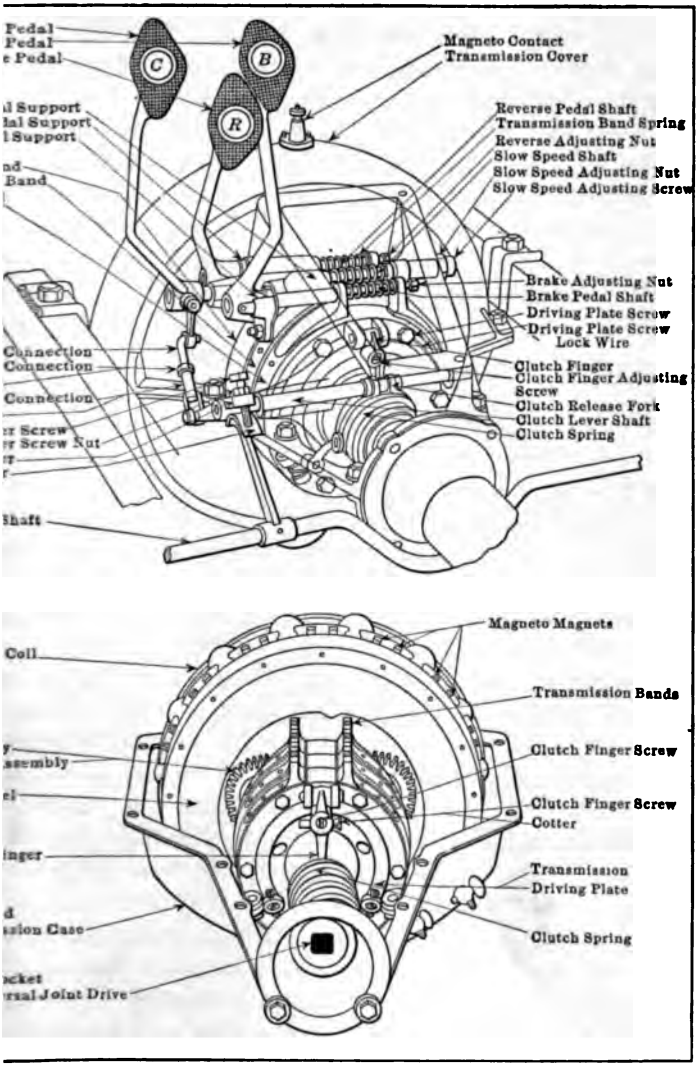

CLUTCH SPRING
DRIVEN SHAFT I
C
B
V
K
P
P1
L
F
D
B
A
DRIVE FROM ENGINE
CLUTCH
S
R
L
D
B
A
C
E
DRIVE SPROCKET
C
BEVEL PINION
DRIVING SLEEVE
BEVEL GEAR
CLUTCH CONE
DIFFERENTIAL
DRIVE SPROCKET

ınetary Gearset Repairs.—The simplest form of geared e speed mechanism is the planetary gearset in its various . It is not the simplest in construction, but it is the easiest trol. At the present time planetary gearing is seldom used, actically all automobiles use the sliding gear type. There ıany cars of early design, however, which use this form of ıg, and it is standard equipment on the Ford automobile. us planetary gear constructions are shown at Fig. 326. That is an all spur type, no internal gears, such as were employed e early forms being utilized. The shafts are divided, the ; the right is geared to the crankshaft and drives the gear C. A is a running fit on the shaft, while gear E is keyed to the at the left, from which the drive is taken. Pinions F, D and B stened together on one common shaft, so that they must rotate nit at all times. Three sets of these gears are provided, these spaced equidistantly in the carrying case. To obtain the speed ratio a contracting band is clamped around the hous-, and when this is held stationary the drive is from the C to the member D, from gear F which turns at the same as gear D to the large driving member E which is attached driving shaft. Reverse speed is obtained by tightening an-band on the drum R. This drum is attached to the gear A ıt when the brake is applied at R the gear A must remain nary. On reverse speed the whole gear carrying housing rotate about the gear A. From the engine shaft the power is nitted to gear C, and from thence to gear D. As three ıs are fastened together any power imparted to these pro-motion of F and B also. When these three gears rotate, E is forced to travel over A, which is stationary, and thus ees rotation of the drum L. From gear D the power is trans-l through gears F and E to the rear. To obtain a high or direct drive the clutch member S is forced against the R so these two members must rotate together; this locks the transmission and causes it to rotate as a unit; as gear A is ed to the drum R it must also rotate with it and the clutch S. ocks the gears F, B and D in position, and as they cannot they act as a lock for the *entire* assembly. The driven shaft

at the left, therefore, turns at the same speed and in the s direction as the driving shaft at the right, which is connecte the engine.

The planetary transmission used on the Ford automobil clearly outlined in part section at Fig. 326, B; the various adj ments and operating pedals are shown at Fig. 327, and a view showing its location relative to the flywheel of the engin shown at Fig. 328. The various adjustments are clearly outli at Fig. 327. The operation is practically the same as the g shown at A, there being three groups of planetary pinions P-1 and K. These are riveted together so they must turn at the s speed. Gear P-1 meshes with gear D, which is keyed to a dri member attached to the drum C. The drive gear F is mounted the end of a bushing which is riveted to the brake drum D. gear L is attached to the brake drum B. The clutch is a multi disc type normally held in engagement by a coil spring.

Three brake bands are used for this transmission, the one t constricts around the drum C is the foot brake and acts to ret movement of the car regardless of whether any of the other clut are engaged. Tightening a band around drum B produces a s speed. When the band is tightened around the drum V or nearest the flywheel, a reverse motion is obtained. To apply ei the slow speed or reverse band it is necessary to break the di driving connection by releasing the clutch spring tension allowing one set of clutch discs to move independently of other set. One set of the clutch plates is carried by the cl case C which is keyed to gear D. The other set is carried clutch disc carrier which is supported by an extension of the gine crankshaft and prevented from turning by a set screw ing through the clutch disc carrier hub into the shaft. The justment of the Ford clutch is a very simple operation, this sisting of releasing the set screws in the clutch fingers by pu out the split pin that acts as a lock and turning in the adju screws. The slow speed adjustment is at the side of the gear and may be reached without removing the cover plate of the t mission which is necessary to adjust either the reverse clutch or the foot brake band.



—Illustrations Showing Method of Adjusting Clutch Bands of Ford Planetary Transmission.

Another planetary transmission which is incorporated with jack shaft unit is shown at Fig. 326, C. This is used on Koehler truck. In operation it is the same as that shown at as three brake bands are provided, one acting as a foot br while the other two provide the reverse and slow speed rati respectively. The contracting band on the transmission serve a service brake. The entire jackshaft unit including bevel driv gears which derive their power from the engine, the different and brake bands are enclosed in a cylindrical housing extend across the frame which is lubricated by oil splash. The count shaft revolves on long main bearings. When it is desired to adj the high speed clutch of the transmissions shown at A and C i necessary to release the locking means and screw the spider m ber carrying the clutch fingers in closer to the drum R in transmission shown at A, while in the Koehler design a si spring pressed plunger lock is provided. When it is desired tighten the clutch this plunger may be withdrawn and the fi carrying spider screwed around as much as necessary. After adjustment is secured it is locked securely by dropping the plu in one of the holes made to receive it on the clutch female me

The chief trouble with a planetary transmission results slipping clutch bands. In all cases these are provided with justments that can be tightened in event of wear of the fri linings up to a certain point. When the friction material w thin, new brake lining must be riveted to the clutch bands. must be taken when making adjustments not to tighten any the bands too much, as if these bind on the drum they will duce friction which results in heating and wearing away of brake lining and will also decrease the efficiency of power tr mission. Noisy action of a planetary transmission is usually ca by excessive wear in the gearing. Slipping of the high speed cl may be easily remedied by making compensation for wear by methods of adjustment previously described. When taking a planetary transmission it is important to note the conditi the bushings on which the planetary pinion groups rotate. these are worn or if the pins supporting them become redu size, the gears will rattle when in use and the transmissi

noisy on low and reverse speeds and when in neutral position, ough it will be silent in action on the high speed.

The brake drum surfaces often become grooved, and these ay be deep enough as to seriously reduce the strength of the

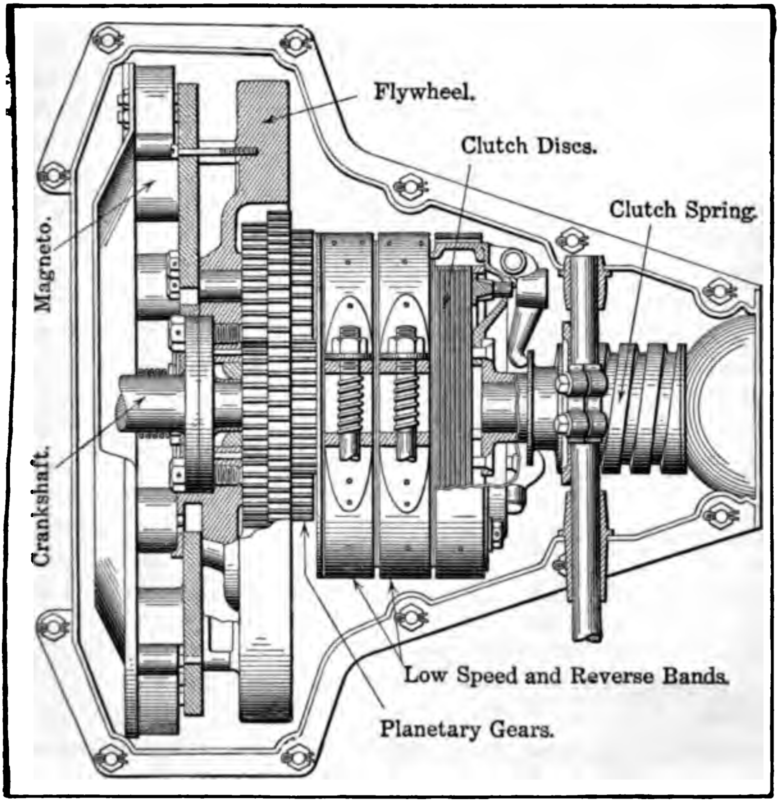


Fig. 328.—Top View of Two Speed and Reverse Planetary Gear Employed on Ford Cars.

rake drum. Where this condition is noted new brake drums must e provided, though in some cases where the brake drum forms art of the *gear containing case*, as in the transmission shown at , *it may be possible to turn* down the surface enough so that

ring of cast iron or steel may be shrunk around the worn drum securely retained to that member by pinning. It is also possi to fill in very deep grooves with cast iron melted in with oxy-acetylene torch and then machining off the surplus mater in a lathe or grinder to bring the drum to proper contour. As gears are always in mesh in a planetary transmission the teeth these members are not likely to wear much, practically all the

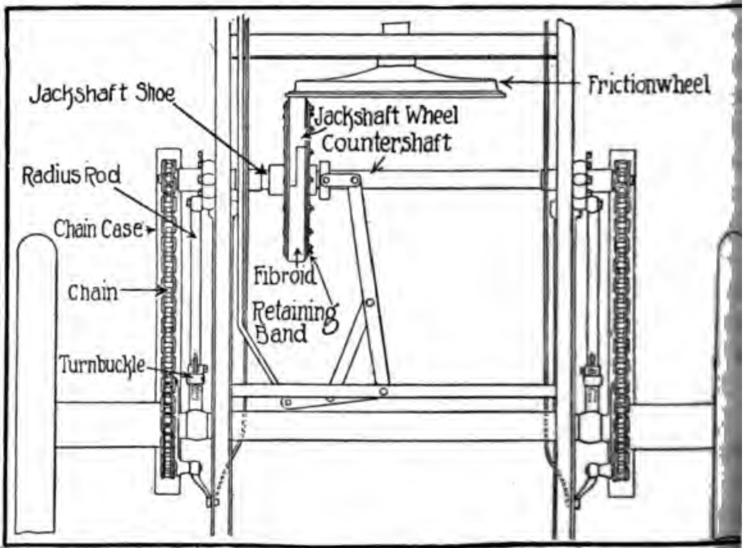


Fig. 329.—Metz Friction Disc Transmission.

preciation existing on the planetary gear supporting bushings pins. In some planetary transmissions the brake drum bushin are short and apt to wear. This also produces noisy action these bushings must be replaced with new ones when worn. C must be taken that all retaining keys and pins are not worn that casing retaining screws are screwed up tightly. The instr tions given for multiple disc clutches in the beginning of this ch ter apply just as well to the clutches used in planetary transmiss when these run in an oil bath.

n Drive Faults and Remedies.—Many cars have been ughout the country, but more particularly in the Middle uipped with friction or rolling traction transmissions of ypes. The simplest form, and the one most widely adopted obile manufacturers, consists of two discs, one driven by e, the other attached to a cross shaft in such a manner n be moved across the face of the engine driven member he various speed ratios. The movable disc consists of a ast iron wheel that is faced with a ring of compressed d or other fibrous material, that driven by the engine is faced with an aluminum-copper alloy, as this combina- been found to give the best results and transmit power xcessive pressure to maintain the parts in frictional con- se drives have not been discussed in trade prints or books as the geared forms, as it is evidently assumed that their makes them easy to understand and maintain. While ery little to get out of order or cause trouble, it is possible ulty may be experienced in transmitting power and the m condemned because one does not know where to look le.

ommon trouble is failure to drive properly, and this may ced by a number of distinct conditions. It may result mulations of oil on the frictional surfaces, which reduce nt of frictional adhesion, "brooming" of the fibrous ma- ar at the face of the aluminum member, spring or lost the countershaft or lost motion at the various members essure linkage that would prevent positive contact of the lements. If the bearings supporting either the cross or ft are defective, or the thrust bearing to which the pedal is applied works stiffly, the increased friction at these ll cause serious diminution of power. In case slipping the first point to examine is the contact surfaces and e that there is no excess of oil between them. If oil re seen, they may be removed with gasoline and the sur- e aluminum plate dusted over with talc or Fuller's earth. tal surface of the driving member is scored, grooved or l, it should be restored to a smooth surface by refacing.

It is possible to do this with a scraper without removing th disc from its shaft and turning it with the engine if car in manipulating the tool. The disc should be turned speed, and after the surface is smoothed to a certain (that the grooves are nearly eliminated, it can be suri moderately fine emery cloth held in a suitable wooden ho moved across the surface by hand. If the grooves are ve

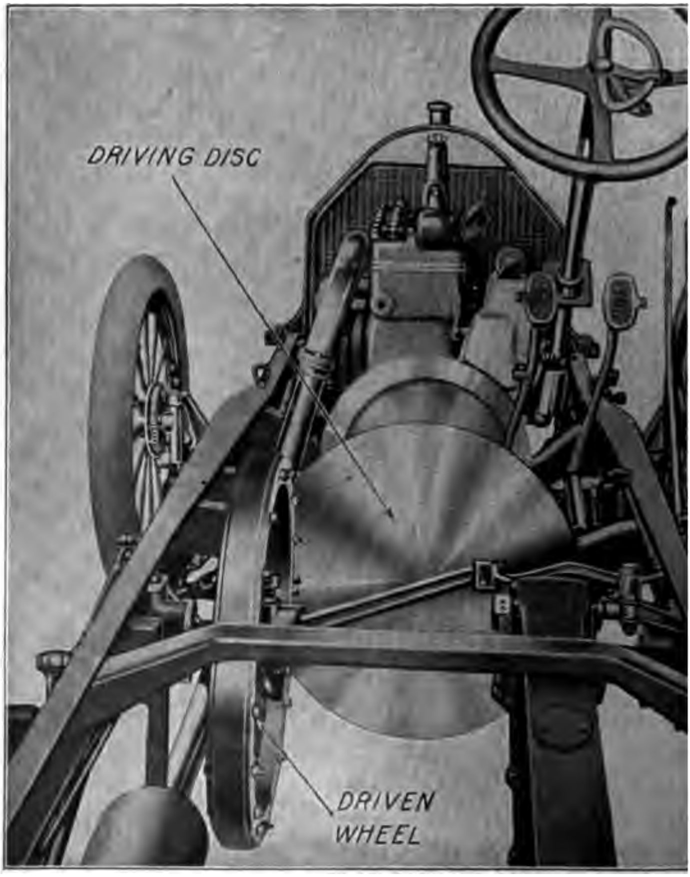


Fig. 330.—The Cartercar Friction Disc Transmission.

may be necessary to resurface the member in a lathe by taking light chip off the face with a cutting tool.

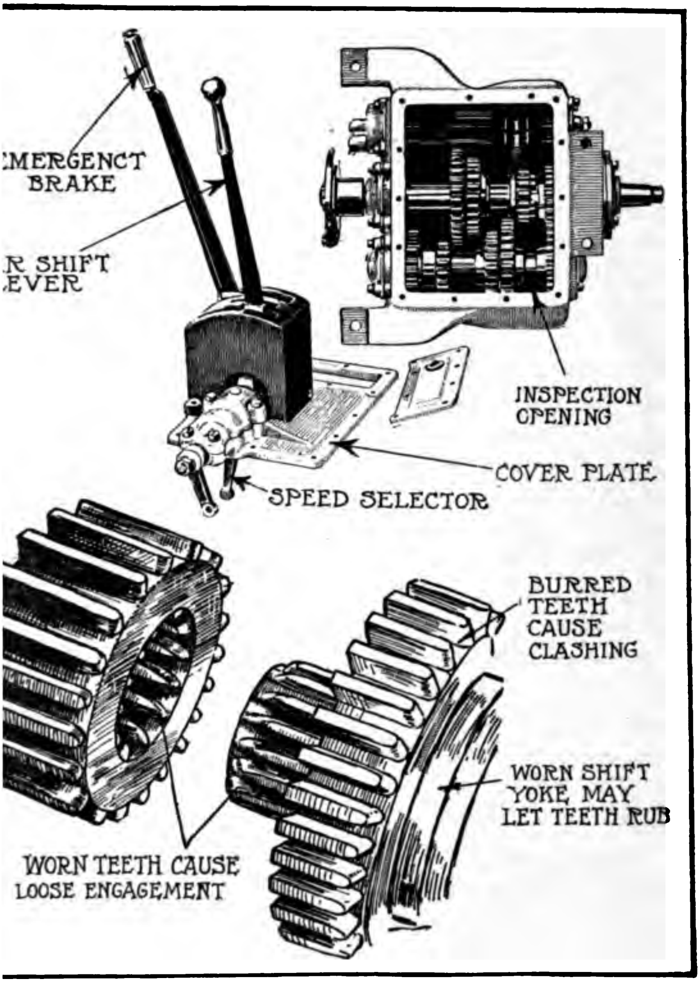
The paper friction ring on the driven wheel flattens out with se and does not last long if the pressure applied to keep the members in contact is unduly high and the surface will become roughned as well. It is customary to renew the paper ring at intervals rresponding to about 2,000 to 3,000 miles average road use. If ny tendency is noted for the driven member to crowd toward ither the edge or center of the aluminum driving disc it can be ttributed to wear in the countershaft or main shaft bearings that ermits either member to sag, and then the line of contact does ot come at the center of the discs which is necessary to secure roper transmission of power. Any condition that will prevent ositive or true contact of the friction members will cause slipping. his means that bearings must be properly maintained and that all ost motion in the operating rods or pressure levers must be miniized. The countershaft should be very heavy and not liable to pring or give when the surfaces are brought together, and the ame member supporting the driving plate must be well braced ith strong gussets to prevent distortion when pressure is applied t the contact surfaces to maintain friction adhesion.

Two typical friction transmissions which are similar in prinple of action are shown in accompanying illustrations. That at ig. 329 is a representation of the friction drive of the Metz autoobile. The view at Fig. 330 shows the arrangement of the parts f the Carter car friction drive. The following instructions peraining to replacing the fibre when worn applies just as well to both rives illustrated. One of the good qualities of the friction drive the ease with which adjustments and replacements are made. he jack shaft wheel or driven member carries what is termed "fibroid" in the Metz car, which is made in two sections to ake for easy displacement as well as renewal. It is retained by locking band secured by bolts as outlined in the sketch. For a riod of time wear of the fibre rings is automatically taken up, t after considerable service and when it has become so worn that e clutch pedal must be pushed to its maximum position, a new justment must be effected in the distance between the friction

wheel and the driven member. This is obtained by adjusting t nuts on the clutch pedal and the drive plate bracket rods a with the clutch pedal released. To replace a worn fibroid with new one the bolts are removed and the retaining band is pull off of the driven wheel. The worn ring is removed in two pie and the halves of the new member are placed on the rim and t ring or retaining band is again secured to the wheel by the bo The parts come all drilled and no difficulty will be experien in replacing the new fibre friction correctly.

Trouble in Sliding Gear Transmission.—When sliding ge transmissions are employed the most common symptoms of derang ment are noisy operation and trouble in shifting gears. The dif culty met with in gear shifting, providing the trouble is not cau by a clutch that does not release promptly, is usually caused b failure of the edges of the teeth of the shifting members, a when these have burred over they will not pass readily into t spaces between the teeth of the gears they engage with. Anot cause of poor gear shifting is depreciation of the bearings, es cially in those types of transmissions using plain bushings. A wear or looseness that may change the center distances of the sh to a certain degree will result in poor meshing because the rela of the gear centers is so changed that the pitch circles will coincide and the tooth of the entering gear may bottom on the of the gear with which it should mesh. Noisy operation when due to mechanical depreciation is usually caused by a defect condition of lubrication. If the gears are not worn too much n may be minimized to a large extent by filling the transmission c with oil of sufficient consistency to cushion the gear teeth, and not be so heavy bodied that it will not flow readily to all beari Difficulty in shifting is sometimes due to binding in the con levers or selective rods, and all points of the gear shifting mec nism should work freely if prompt gear shifting is required.

If considerable difficulty is experienced in meshing the ge and the trouble is not found in the gearset, it will be well to ex ine the clutch to see that the driven member furnishing pow the gearset primary shaft does not "spin" or continue to rev after the foot pedal is depressed. It might be stated in this



1.—View of Jeffery Transmission with Cover Plate Removed at p, Common Causes of Poor Gear Shifting Outlined in Lower ustration.

that on most of the modern cars having clutches of such ction that spinning may result, clutch brakes are provided e *are used constantly* the friction pad, which is often

limited area, may wear, in which case renewal is necessary restore the clutch to efficiency.

Fortunately, most gear boxes are built in such a way that t interior may be readily examined. An example of a large openi provided in a gear box by removing a cover plate is shown at t top of Fig. 331. This is the gearset used on the Jeffery fou cylinder cars. The construction of the various gears as well as t selective members is clearly shown. The control levers are attach to the transmission cover plate, as indicated, but may be readi removed with the cover by taking out the bolts holding that memb in place and uncoupling the emergency brake actuating rod. T speed selector, which is actuated by the gear shift lever, fits in suitable depressions in the sliding gear shift rod.

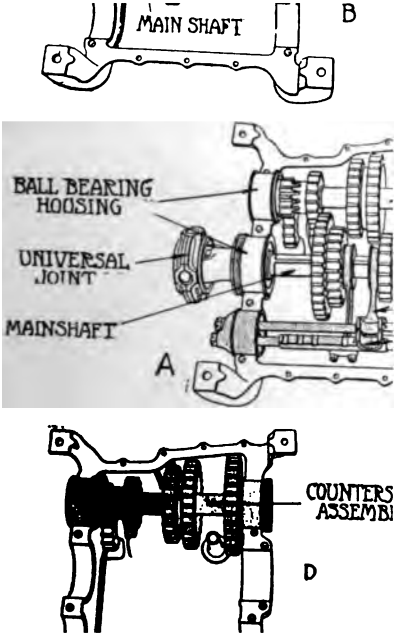
In some transmissions of the sliding gear type the high spe or direct drive is obtained by the sliding gear which provides t intermediate speed having a suitable extension from its face d signed to mesh with an internal gear and thus form a positi driving clutch to couple the gearset main shaft portions togeth When the teeth on the male clutch member become worn cons erable trouble will be experienced in securing positive engageme and if the wear is such that the width of the teeth is materia reduced a new member will be needed. If the teeth are not wor but are only burred over at the edges, they may be dressed proper contour by using a very small, high speed emery wheel the end of a flexible shaft or by removing the offending memb and grinding it in any suitable machine.

Some garage mechanics will anneal a gear in order to soften sufficiently so that the rough piece may be smoothed with a fi Attempts are afterward made to harden the gear and seldom these result successfully. In modern gear boxes chrome and nic alloy steels are used which demand careful heat treatment in ord to secure the best quality of steel. These have been carefu developed by scientific laboratory tests and heat treatments seldom duplicated with the equipment available in the ordin repair shop. The repairman should not anneal gears unless he confident that he can treat them properly in rehardening. T means that the nature of the stock as regards its chemical c

osition must be known and that the best quenching point for that articular alloy must also be determined. The use of a small, igh speed emery wheel will make it possible for the mechanic to ress the gear without softening it or altering its nature, as an mery wheel will cut hardened steel very easily.

Whenever an old gear is removed and is to be replaced by a new one, it is well to make a rough sketch of the gear you desire, indicating the number of teeth, the pitch, the width, the diameter of the gear and the size of the hole going through it. This insures the receipt of a gear that will fit the defective gearbox, and not one for a later or earlier model car of the same make as that worked on. When the cover is off of the gearbox, as shown at the top of Fig. 331, it is possible to test the amount of wear between the shifting yokes and the portion of the sliding gear members on which they fit. On some selective gearsets there is not much space llowed between the gear teeth, and if the shifting yoke wears it nay be possible for the shifting gears to rub against one of the ixed gears on the counter shaft and produce noise. The main and ountershaft bearings may also be inspected and tested for looseess by grasping the shaft firmly and attempting to move them p and down or from side to side.

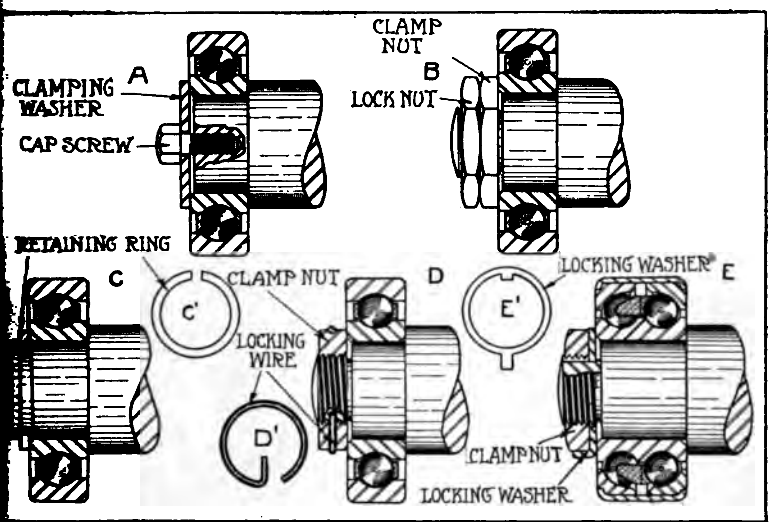
If the various components of the gearset are found defective he gear box must be taken apart and given a thorough overhauling. The means of accomplishing this depends entirely upon the design f the change-speed gearing. In those cars where the gearset is nounted under the floor boards as a separate unit, the entire gearox may be removed without disturbing the power plant or clutch ssembly. Gearboxes of this form are usually of the horizontally livided type, and when the top half of the gearbox is removed he various gears and shafts, as well as speed selecting members, re exposed as shown at Fig. 332, A. The first step is to remove he shifting members which are shown shaded at A, this leaving he main shaft and countershaft in place as shown at B. The ext operation is to lift the main shaft out, which leaves the gear ox as shown at C. After the primary shaft is removed only the ountershaft *assembly and the* reverse stud gear are left in mesh, *s shown at D. Lifting the* countershaft out leaves only the botto



MAIN SHAFT
B
BALL BEARING HOOSING
UNIVERSAL JOINT
MAINSHAFT
A
D

e gears, the shaft to which they are keyed, and the supporting arings and their housing, is replaced in position. Next the imary shaft member is put in, then the main shaft, and lastly e control members or shifting rods, until the gearbox is again shown at A, and ready for bolting the top part in place.

The bearings used on the ends of the countershaft are often the ball form, as shown at Fig. 333. Different methods of re-



ig. 333.—Conventional Methods of Retaining Ball Bearing Inner Races on Sliding Gearset Countershaft.

ining the bearing in place are followed. That at A shows the e of a cap screw and clamping washer. At B a clamp nut is ed to press the bearing inner race firmly against the shoulder the shaft, while a lock nut keeps the clamp nut in place. A y simple method, and one that is entirely satisfactory, is shown C. This consists of grooving the end of the shaft circumfer-tially and putting in a split ring, as shown at C. A common hod of retaining the bearing inner race, and one recommended ball bearing manufacturers, is shown at D. After the clamp 's brought tightly against the face of the inner race a locking

wire is sprung around the nut and the point entered into a s drill hole which goes through the nut into the shaft as inc Another method having much in its favor is shown at E. a double row ball bearing is pressed against the shoulde

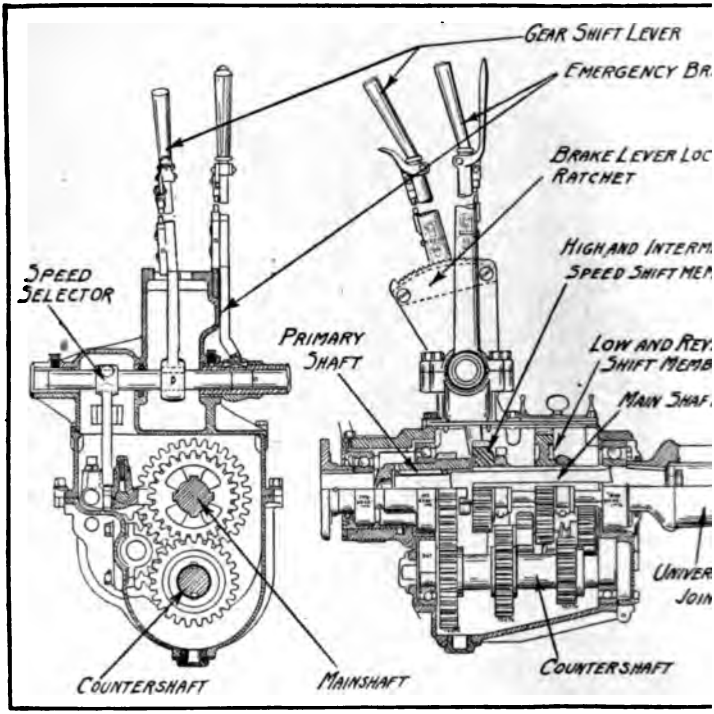
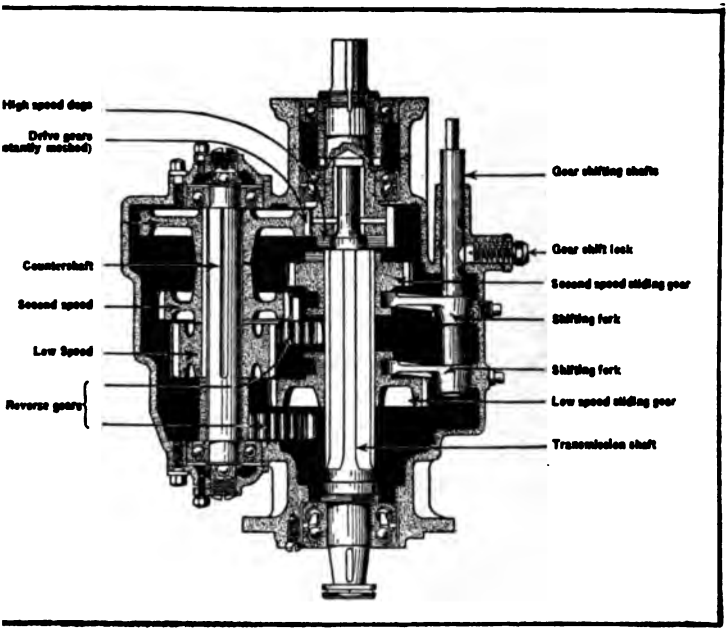


Fig. 334.—Diagram Showing Construction of National Three Sp Sliding Gearset.

clamping nut which is separated from the bearing inner f a locking washer of the form shown at E′. This has one pro on its inner periphery designed to engage a keyway cut shaft. The projection on the outer periphery is intended bent around one of the facets of the nut to hold it in plac it has been firmly seated against the locking washer and l inner race. Complete instructions for the maintenance and

ı of ball bearings and other anti-friction forms will be found ıapter IX., which deals with rear axle construction.

ıe construction of a typical three speed forward and reverse ive transmission showing ball bearings and gear shift members ırly shown at Fig. 334. This has the gear shaft and emergency levers carried by a suitable supporting casting forming part



'ig. 335.—Three Speed Sliding Gearset, Forming Part of Rear Construction of Overland Automobiles.

: gear case cover. In this gear box single row ball bearings ;ed at all points, except to support the telescoping end of the shaft, which fits into the primary shaft and which rotates ·oller bearing. The primary shaft is supported by two single ıearings, the outer one being clamped so it holds the shaft r while the inner and larger one has a floating outer race. *a ball bearing is clamped* on both inner and outer races it

will take end thrust as well as radial load. A thrust an endwise load, while a radial stress is a load applie up-and-down direction or sidewise. In this gearset tl inner races on the countershaft are pushed on tightly, t a force fit on the shaft ends. No retention means are The general construction of this gear box, which is th National cars, is so clearly shown that further descrip necessary.

A three speed and reverse sliding gear set that for the rear construction on Overland cars is clearly sho

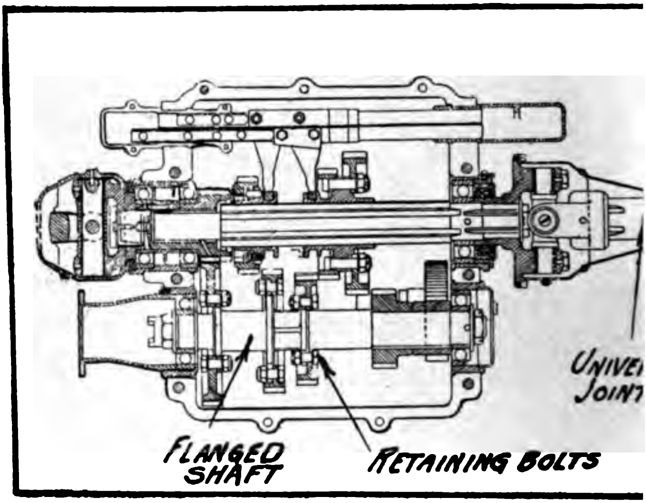


Fig. 336.—Four Speed Selective Sliding Gearset of Approve

335. In this the primary shaft is carried on single row ball bearings, while the end of the main shaft to bevel driving pinion is secured is supported by a large bearing which is capable of taking end thrust and rad combination. The single row bearings on the end of tl shaft are subjected to radial loads only as the counters from end movement by simple thrust members compose ball fitting into an adjustable screw plug. The gear shi

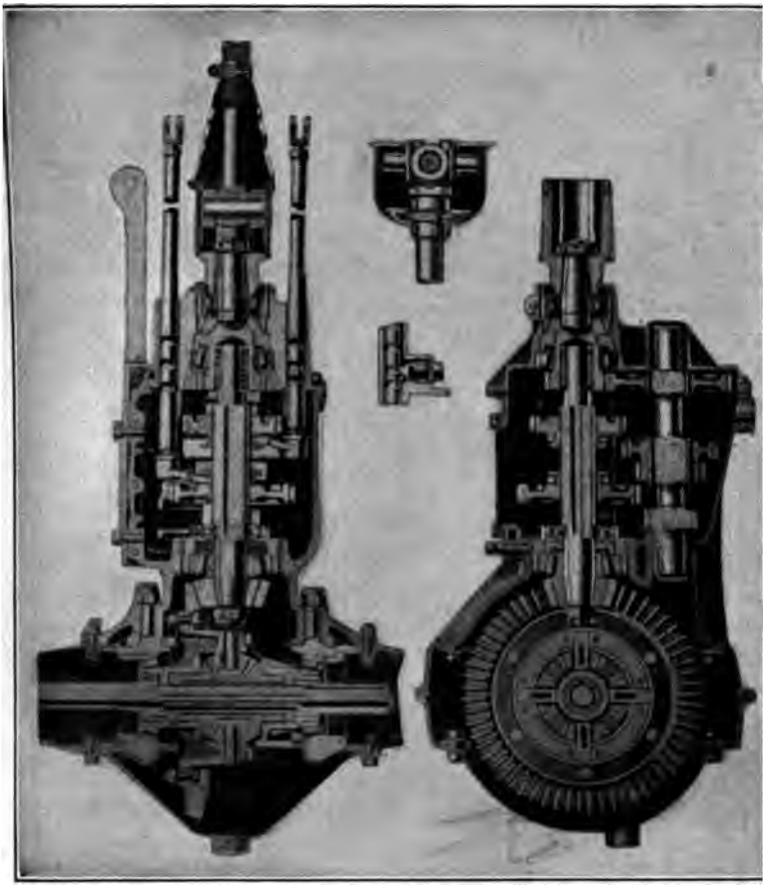


Fig. 337.—Showing Application of Three Speed Sliding Gearset to Studebaker Rear Axle.

are attached to the gear shifting shafts by means of taper pins which may be driven out to release the forks and permit of taking the transmission apart by removing pipe plugs in the side of the gear case which gives access to the retaining pins when the sliding gear members are in the neutral position as indicated.

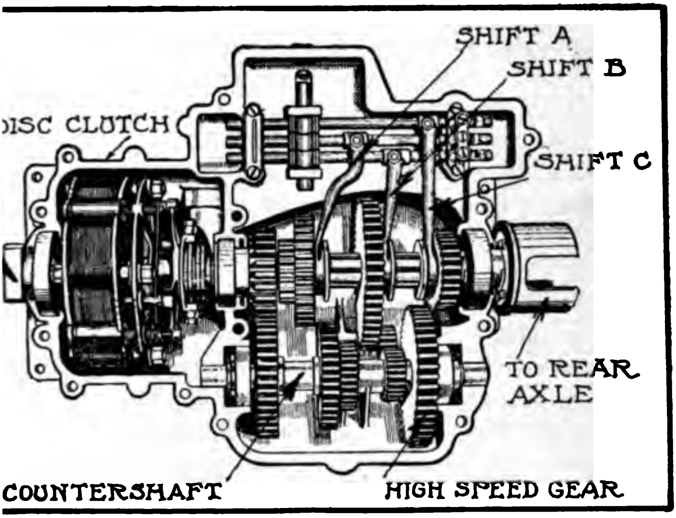
In some gear boxes, especially those used on high-priced aut

mobiles, the gears are in the form of rings which may be bolted the shifting members and to flanges on the countershaft as shown Fig. 336. The point advanced in favor of this construction is th it is possible to renew only the defective toothed ring instead replacing an entire shifting member as is necessary when the gea and hubs are formed integrally. It is also contended that the u of bolts to hold the gears firmly against flanges machined integral with the countershaft makes for more secure attachment than t cheaper method of keying. The gear box design shown is used onl on high-powered cars, where secure means of retaining the gea are absolutely necessary. A gear box of this design is very cost to manufacture, but it is cheaper to keep it in repair than t simpler forms.

The change speed gearing is often combined on the rear axl as shown at Fig. 337. This outlines a top sectional view throu the rear construction and a side sectional view showing the di position of parts very clearly. It will be observed that the bev pinion carried on the back of the main shaft drives the bevel rin gear attached to the differential housing directly. As the gear b is part of the rear construction it is possible to secure exact alig ment between the driving gears, and no power is lost due to faul alignment between these members as may sometimes occur wh the gear box and rear axle are separate components and the fra is distorted due to rough roads.

A four speed gear box having clutch integral, a somewhat u common construction, is shown at Fig. 338. This design is us on some models of the Winton automobile. Three shifting yo are used, shift member A controlling the direct drive, which i this case is a third speed, and the second speed. Shift member gives the first or lowest forward speed and the reverse ratio. Shi member C is used to engage the fourth speed, which is a high rat obtained through speeding up gears instead of reduction gea With gear sets of this character all normal driving is intended be done on the third speed or direct drive. The geared-up fou speed is called upon only when conditions are favorable and hi vehicle speed is desired. This gearset is a form in which but lit *clearance* obtains between the shifting members and the non-sh

and is a form where depreciation of the shifting yokes t in the gears grating even when in neutral position. se forms of gear boxes where the ends of the shafts are by single row ball bearings with no special provision hrust, noisy action may result in a very short time due nment of the ball bearings at the end of the shaft. When- ;hifting members are moved to change a gear a pressure 5 to 100 pounds is exerted through the shifting yokes on



—The Winton Four Speed Sliding Gearset, Having Geared Up Speed, and with Clutch Carried in Gear Case Extension.

g gear members, and if these do not engage promptly ure becomes an end thrust in the ball bearing. It is only ie are new and practically unused that this pressure can d without pushing one of the ball races a trifle out of the other. As soon as the wear in a radial ball bearing to a few thousandths of an inch, which does not appre- ect the radial capacity of the bearing, the balls can yield rust or lateral pressure to a certain extent and an end- ement of the shaft results whenever an end thrust is

applied due to poor engagement of the shifting gears. It i
only the pressure from the gear lever that must be taken
account, but the endwise shocks received in changing from a l
to a high gear also assist in producing depreciation at the bea
The theoretically correct parallelism of the main and counter
is eventually lost if a suitable allowance in the dimensions o
different ball bearings does not serve to equalize the wear d
radial load in the ball bearings at both ends of each shaft.
the gear tooth pressure is highest at the ends where it is t
mitted with a large speed reduction to the low gear, this
applies specially to commercial vehicles in which the low ge
used more than in pleasure car service.

Where the use of special end thrust bearings is considere
expensive, adjustable hardened end thrust sustaining members,
as shown at Figs. 335 and 338, may be used at the ends o
countershaft. Owing to the lack of solidity of aluminum gear
castings, it is usually the plan in constructions of good de
such as at Figs. 332, 334 and 336, to mount the bearings in fl
steel or bronze housings in order to enlarge the areas over w
the bearing pressures are transmitted to the soft aluminum. N
gear box action is sometimes produced due to thin gear box w
which possess sound magnifying qualities, and this feature a
may multiply the volume of noise that would normally be ca
by the gear action three or four times, especially if the bearings i
located in such a way as to set the gear box in vibration when wo
The only way noise can be reduced is by keeping the ball beari
in proper condition and filling the gearset with a viscous lubrica
such as pure mineral grease, which will provide a cushioning eff
against the vibration produced by roughness in either gears
bearings.

CHAPTER VIII

FAULTS IN CHASSIS COMPONENTS

hassis Types—Dismantling a Chassis—Straightening a Bent Frame—Trussing a Weak Frame—Repairing Cracked Side Member—Care and Repair of Springs and Spring Parts—Compensating for Steering Gear Deterioration—Drag Link and Tie-Bar Repairs—Testing Wheel Alignment—Radius Rods, Torque Members and Control Linkage—Universal Joint Forms and Troubles—Front Wheel Adjustment—Muffler Faults—Chassis Lubrication—Locating Acetylene Gas Leak.

EVEN after the power plant and gearset have received attention, here are numerous points about the chassis of the car that should e inspected if a thorough overhauling is called for. The chassis f any well built car will need but very little attention if the rious parts are well oiled until it has been used from ten to teen thousand miles. After this distance has been covered, the otorists will probably be annoyed by a series of squeaks and ratts, even though the engine and gearset are in perfect running ndition. These rattling noises indicate wear at a number of latively unimportant bearing points, and even though the depreation is slight, the looseness at the multiplicity of small joints ll produce a noise that will be unmistakable whenever the car operated on other than perfectly smooth highways. Among some the things to be looked for are wear in the various control kage members, sagging or bent frame side members, loose cross mbers or gusset plates, due to rivets having loosened up in sere; stiff action of the springs, due to rust accumulating between leaves; looseness in the steering gear and steering connections, k of alignment of the front and rear wheels, looseness of the eel hub bearings, and numerous other conditions that will be merated and discussed in this and the following chapter.

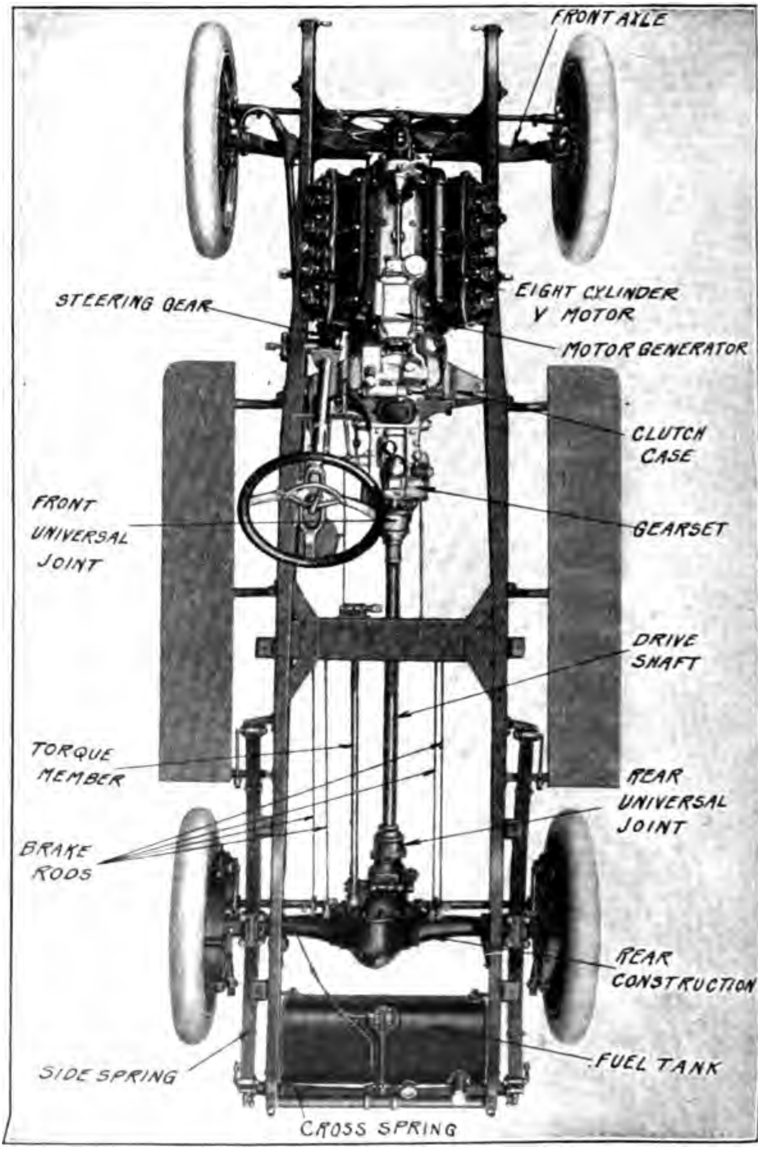


Fig. [illegible]—Plan View of the Cadillac 1915 Chassis, Showing Location of Eight Cylinder V Motor and Unit Gear Set.

'ypes.—Before discussing the points to be inspected ıer of making repairs when defects are found, it may scribe briefly some of the typical chassis constructions , the novice repairman may get an idea of the rela- parts in cars of conventional design. The side and f a National four-cylinder chassis are shown at Fig. important components being clearly indicated. This dered a good example of high grade car construction power plant and change speed gearing are separate apparent, the engine may be removed from the frame urbing the change speed gearset while the gear box n out without requiring the removal of the engine. construction of this chassis is conventional and follows utomobile engineering practice. It has the virtue of arts readily accessible so that repairs may be easily t disturbing other components except those that are upon.

view at Fig. 340 shows a chassis of recent development the Cadillac Company which is provided with an V engine having the transmission gearing incorpor- with the engine crankcase. This construction is more n the usual unit power plant is, owing to the design s of removing the transmission case from the engine disturbing the power plant. In all other respects follows conventional practice. The important parts own and no difficulty should be experienced in iden- on the actual chassis.

rman will be more often called upon to repair motor future than he has been in the past on account of g popularity of the heavy duty vehicle. The chassis in the main follows the design established in pleasure excepting for the use of much stronger parts and a ise standard structural steel shapes for frames instead pressed steel side members commonly found in pleas- e. The average truck chassis will have a pronounced r the front and rear axles in order to obtain a body size without unduly increasing the wheel base. Gear

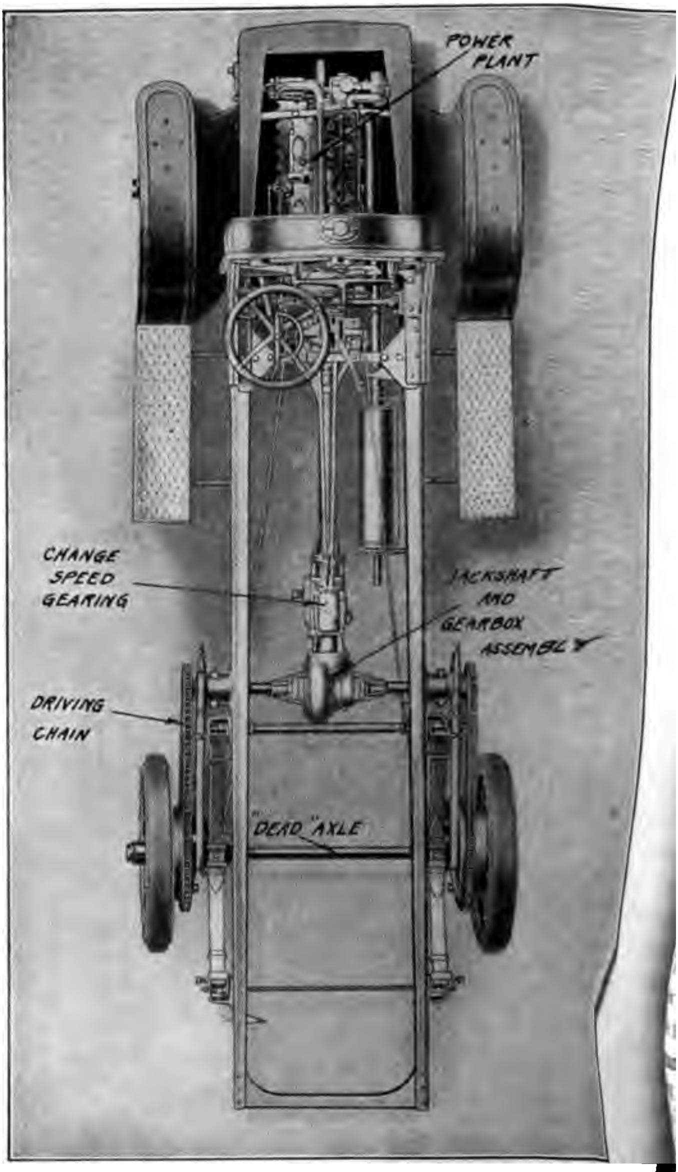


Fig. 342.—Plan View of Typical Chain Driven Motor Truck Chassis

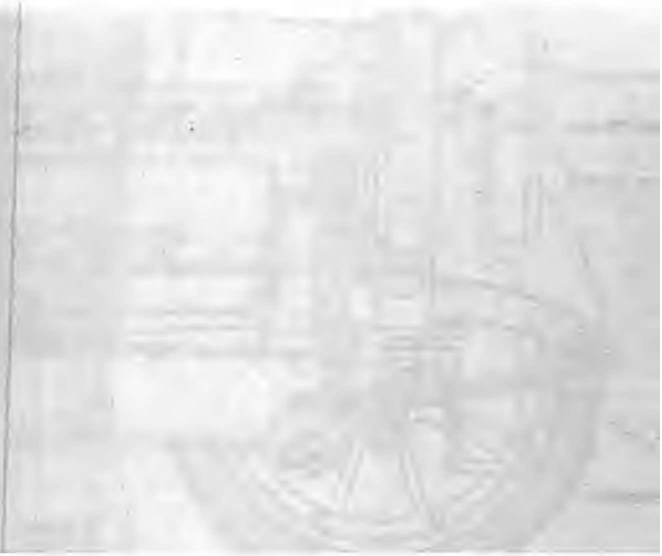
lo not differ materially in construction as far as rela- is concerned from pleasure cars of the present-day orm drive and double reduction axles are rapidly and the conventional side chain drive construction . of the trucks have been built is gradually being ıe more modern forms having a live axle instead of rotating member shown at Fig. 342. It will be re- those who have had automobile experience, dating a ırs back, that many of the powerful pleasure cars ı side chain driving systems. The power transmission shaft which was practically a live rear axle having e axle ends instead of wheels, and from that member eels, which were revolved on a nonrotatable axle by ing chains. The process of taking down a motor nd the points to inspect for depreciation would not ly from that used in repairing a pleasure car assem- o the use of solid rubber tires, a motor truck is ıuch more vibration than a pleasure car, and con- : attention should be given to the running gear may become loose much sooner than on the pleasure of the load is carried by very resilient pneumatic

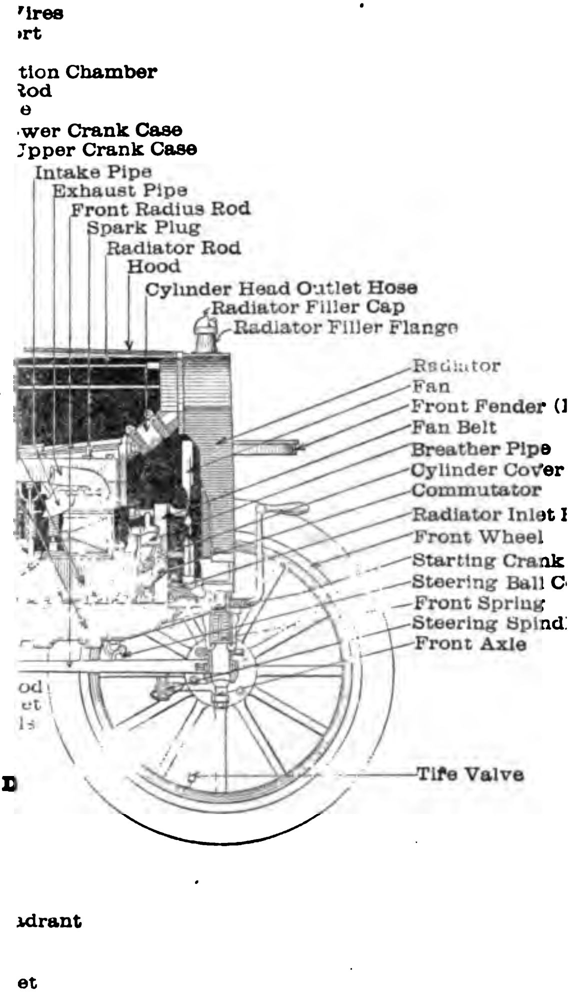
on automobile repairing would be complete without s of the Ford model T automobile, which is the most ıotor vehicle in the world. The reader's attention the very clear sectional view shown at Fig. 343 for arrangement of parts on this universally used motor ous parts are clearly outlined and may be located the leader lines to their termination at the arrow her end indicates the name of the component. The ig. 344 gives an idea of the appearance when viewed

g a Chassis.—The various steps incidental to dis- otor car chassis to give all parts a thorough over- wn at Fig. 345. The plan view showing the appear- ıssis of a Locomobile car at A denotes the appearance and fenders have been removed. It is always ad-

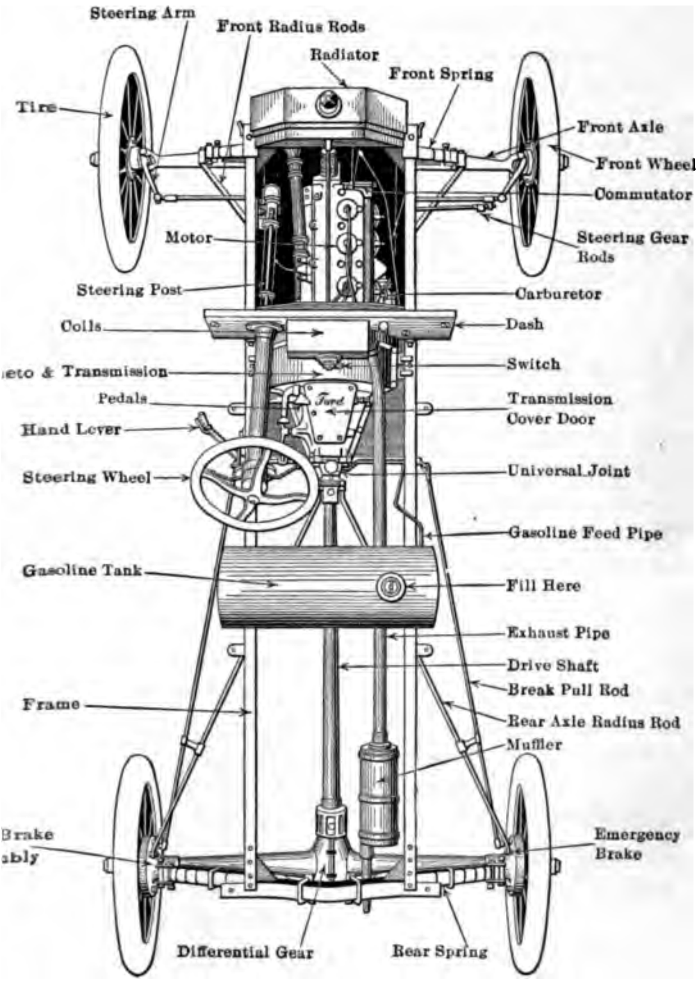
visable to remove the body and the mud guards befor is done upon the chassis, and in case of an extended much time can be saved by sending the body and gu paint shop while work is being done on the chassis. sirable because the finish of the body is much more imp that of the chassis parts, and it takes more time for to do an enduring painting job on the body than on t gear. The next step is to remove the running boards a board irons, if these members are fastened to the fran If the running board supporting members are riveted tc it is not necessary to remove these unless the frame side to be re-enforced. The wheels are removed from the rear axles and the frame supported by special jacks. Tl easily made by using substantial cast iron base plates a in diameter in which a piece of two-inch pipe is s sliding arm of cast iron made with either a cam or g or having a strong set screw to keep it in place when the proper height, is adapted to move up and down th some cases holes are drilled through the pipe and a ste through it on which the supporting arm is allowed to 1 frame supports have the advantage of not interferin removal of the various chassis components as they supp weight directly under the frame sides instead of throu dium of the axles and springs as the ordinary liftin Four of these stands are used, two on each side of the

The appearance of the chassis with the running wheels removed is shown at Fig. 345, B. The next st move the radiator, the steering gear and the change controlling members. The clutch and brake pedal cross also be taken from the chassis at this time. This leaves in the condition shown at C, Fig. 345. The next step off the rear axle, including the propeller drive shaft, tc ber and radius rods. The chassis then has the appearan After the removal of the change speed gearing the pai shown at E. The dashboard assembly and the engine are off the frame, which leaves the frame as shown at F. A only the front axle and rear springs are retained. Wl





'ires
ırt
tion Chamber
Rod
e
wer Crank Case
Upper Crank Case
Intake Pipe
Exhaust Pipe
Front Radius Rod
Spark Plug
Radiator Rod
Hood
Cylinder Head Outlet Hose
Radiator Filler Cap
Radiator Filler Flange
Radiator
Fan
Front Fender (
Fan Belt
Breather Pipe
Cylinder Cover
Commutator
Radiator Inlet
Front Wheel
Starting Crank
Steering Ball C
Front Spring
Steering Spind
Front Axle
od
et
ls
Tire Valve
D
adrant
et



344.—Plan View Showing Location of Chassis Components of Ford Model T Car.

parts, including the front axle and the front and rear spring removed nothing but the bare frame, as shown at G, is left.

It is seldom necessary to strip a car down to the point s at F or G, unless repairs are needed on the frame and the in parts cannot be reached with the various power plant and mission units in place. The reason for the removal of such as the motor, steering gear, change speed gear box and as that these can always be more conveniently worked on if supp on special stands adapted to receive them. Many of these been described in an earlier chapter when speaking of shop ture. Obviously the process of reassembling would be just t verse of that outlined for taking the chassis apart. Starting the bare frame shown at G, one would add the springs and axle as at F, then install the power plant and dashboard ass as at E, couple up the change speed gearing as at D, then p the rear axle and the various connections as at C. The ste gear, radiator and various control rods and levers would th put in place, as well as the muffler assembly, which would the chassis to the almost completed state outlined at B. The tion of the running boards and their supporting irons, the brakes and brake rod linkage, would then complete the cha shown at Fig. 345, A.

The various retention means, such as bolts and lock wash well as other forms of lock members, are described in the c dealing with special repair processes. The most common f nut retention is by employing a split pin in connection castellated nut. A number of tools have been described for pin removal, but many owners of cars do not possess anyth the tools furnished with the repair kit. Two methods o this work easily which do not require the use of a special shown at Fig. 346. One of the best ways for getting an o split pin out of the hole is shown at the top of the illu The pin is grasped between the ordinary combination pli and a hammer is used against the plier to draw out the p other method, which is shown below, consists of insertin drift pin or nail set through the hole in the cotter pin h then striking the drift with a hammer. It will be found

[illegible]

l of the pin will be expedited considerably by squeezing the gether, if they are spread, with the pliers before attempting draw the pin from the hole.

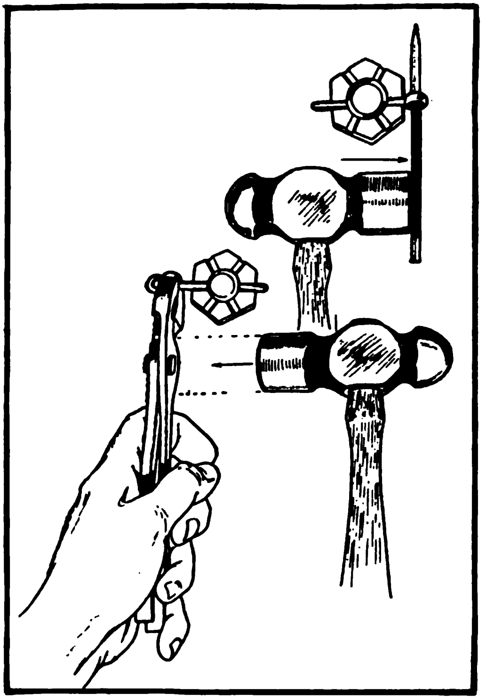


Fig. 346.—Simple Method of Extracting Split Cotter Pins.

ery good method porting the front end of a mo- frame, if there rojecting parts, vn at Fig. 347. onsists of plac- flat bar of steel the frame just f the spring and by using a horse or trestle the iron bars to o r t the weight vehicle. The s may then be off without dis- the axle and connection, if re the only mem- hat demand at- . If it becomes ry to move the any time while rse is in place, ace between the frame and axle may be filled by blocks of which become temporary spacing members and which will the weight of the car to rest on the axle. The same method e used in supporting the frame in event of a complete over- g being necessary.

aightening Bent Frame Member.—One of the most common to a frame is straightening a spring horn or dumb iron in of a collision. A very simple and effective method of per- g this work is shown at Fig. 348, providing that the frame

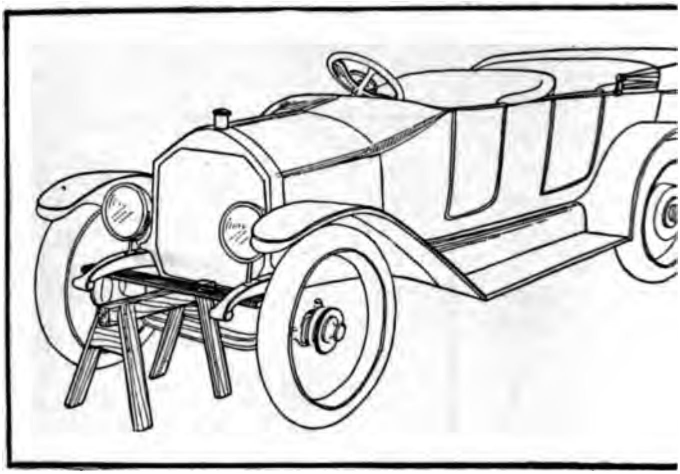


Fig. 347.—Outlining Method of Supporting Front End of M Frame When It is Desired to Remove Either Front Springs Axle.

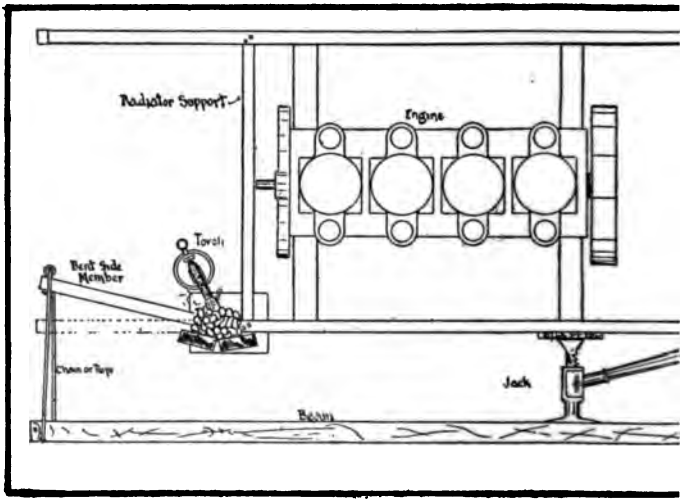


Fig. 348.—Showing Method of Straightening Bent Frame Side

bent forward of the radiator support and that the shock has not racked or materially injured the metal. If the frame side is racked it will be well to straighten it to its original form and then ll in the cracks with new steel by the oxy-acetylene process. If ie frame is merely bent, straightening to its original form will be l that is necessary to effect a permanent repair. The radiator ould be removed, as well as the front axle and the springs. The ont of the machine is supported by blocking under the frame embers or by any suitable stand. The body should be raised from e chassis about four inches at the front end so that a loop of ain can be passed around the frame member to act as an anchorge for a piece of joist used in straightening the side members.

A piece of sheet steel is placed under the frame and supported the box, the top of which has been covered with about 3 inches sand. A rough furnace may be constructed of firebrick and the me covered with charcoal, a slab of firebrick serving to keep e heat confined to the bent portion of the frame. A large gasone blow torch is employed in connection with the burning charcoal ad sufficient heat is applied to bring the frame side to a cherry d heat for several inches each side of the bend. The torch is t aside and while one man carefully manipulates the jack, which best placed against a piece of board resting on the frame member the point where the engine support is bolted or where a cross ace is riveted, an assistant facilitates the work by hammering ad contouring the heated section to bring it back into shape. A acksmith's "flatter" should be interposed between hammer and ame in order not to dent the frame side, as might be done if e hammer blows were directed against the heated member. The raightening can be done only while the frame member is hot ugh to show color, and as soon as the redness is lost the torch st be again applied to heat the bent section before any further rk is done. A block of wood may be interposed between the me channel so the chain or bar loop at either end of the beam s not crush in the metal where pressure is applied. The sketch nly shows the manner of doing the work and the use of the s to effect a very satisfactory restoration.

russing Weak Frame.—The frame side members sometimes

sag after the car has been used for a period, especially operated at high speeds over rough roads, or in the case of truck that has been made to carry overloads. A weak cha tion member of this character can be made stronger by two methods. It may be re-enforced by a plate rivete

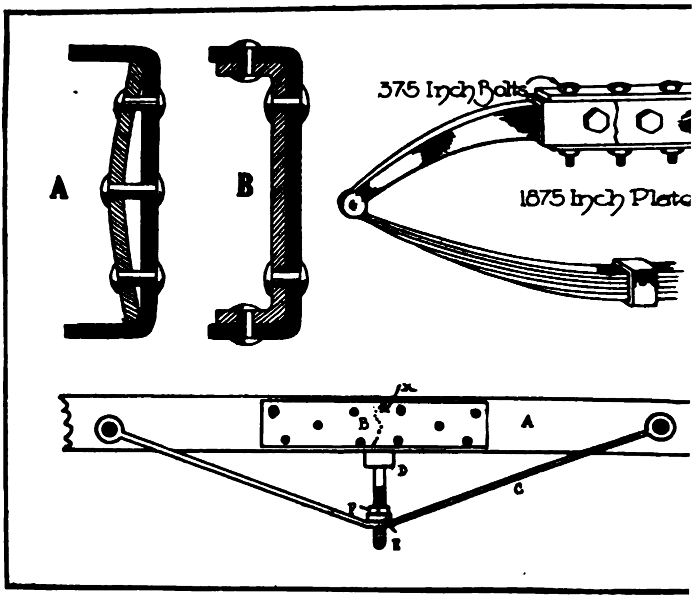


Fig. 349.—Methods of Repairing Cracked Frame Side Me

interior or it may be trussed by truss bar and turnbuckle ment. Sometimes a plate is added to both inside and o the frame and the whole held together by rivets or bo best method where conditions permit is to use the inside r ment as shown at Fig. 349, B. When correctly applied, portions properly worked out, this results in the greatest The sketch shows two common methods, one correct, the correct. Instead of using a wide flat plate, slightly g height than the inside distance between the upper and low of the channel, the re-enforcing member should fit the i

e channel closely, as at B. The wide plate method shown at A wrong for two reasons, the first being that the main frame gains tle strength from the plate and but a small amount from the stening, where the mounting is such that these are subjected to ternal stresses which may break them without considering the ternal forces acting on the frame. The fillet in the corners the channel make the accurate fitting of such a plate a very lious job, so that usually a compromise is accepted and the re-forcing members driven in by brute force.

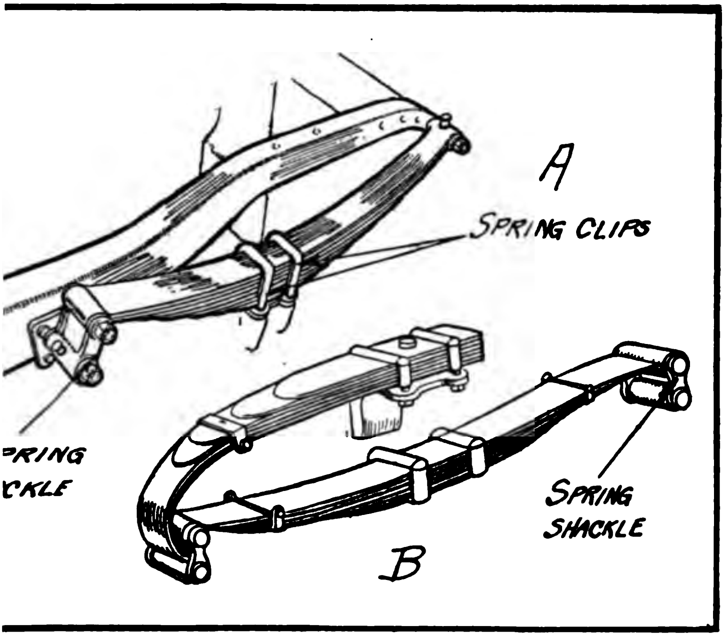
The repair plan outlined at B is a much better one, as in this a de sheet of fairly thick metal is forged to channel shape so it s the inside of the frame closely. The contour of the interior the section may be readily found by making a template of light eet metal. The re-enforcing member should be just a trifle larger an the interior of the frame, as it must be driven in place when sembled. It is then attached to the side as well as at the top d bottom of the channel by bolting or riveting. These fastenings d much stiffness and strength while the placing of the retaining lts or rivets will not allow of any shifting of parts after the enforcing plate is once installed. While it requires a little more e to make than the former, it will give considerably more ength and last many times as long. If the weak spot or crack t only one point, a ten-inch plate will do, but if the weak zone wider than this greater lengths must be used. The method out-ed to the right of B involves placing plates on both sides as well top and bottom of the spring horn. This repair is an unsightly e and a much better repair can be made by using the autogenous ding process instead of the clamping plates. No matter what ocess is employed, it is necessary to bring the injured portions the frame together in the same relation they occupied before turing.

Sagging side members in cars of the form where the engine and box are separate units may not be apparent except by diffi-y in gear shifting, owing to lack of alignment between the ch and gearset shaft or binding in the gear shifting mechanism. condition is specially noticeable in cars using wood frames. the construction permits, a truss rod forms a very effective

means of straightening up a sagging side member and preve
a recurrence of that trouble. The illustration at the lower
of Fig. 349 shows one method of re-enforcing a side member, tl
the adjustable member, to draw the frame together, can b
as well made in the form of a turnbuckle and placed on on
of the brace rod. In the cut letter A indicates the side me
B the repair plate with sliding bolts and lock washers, C the
rod and manner of attachment, D a bolt with an enlarged su
ing head, E the flat enlargement of the truss rod to secure suf
metal to have a hole to receive the truss bolt D, F a tensio
on the truss bolt. The advantage of this repair is that it
be made at any country blacksmith's shop, whereas the fitti
a turnbuckle usually requires machine shop facilities. Th
is placed under the cracked portion indicated by X, and t
is produced in the truss rod C by screwing down the nut
the bolt D. The truss rod may extend from the front to th
end when the side member is sagging, and would be longer
that indicated for supporting the cracked side members. I
case the truss would resemble that used in bracing freigh
floors, in that it would have two supporting members in the
of castings under the frame spaced far enough apart so ther
be a length of straight rod joining them in which the turnl
would be placed. The best method of anchoring the ends
truss rod to a frame is to make an eye member in each end
rod and to have a forged I member with a flattened portion th
be fastened to the frame side by substantial bolts to attac
rod ends to. Care should be taken in tightening up the truss
bers not to buckle the frame side rail to the other extreme af
has been straightened out.

It is not unusual to find the rivets at the corners of a
or those holding cross members and gussets or re-enforcing
loose. If they are not very loose, satisfactory repairs can
be made by peening them over again, using a heavy hamme
a suitable anvil or rivet set to receive the force of the ha
blow. A rivet set for frame work may be easily made by t
a large bar of square or round section iron or steel, three feet
and two inches in diameter, and turning up one end at

to the bar about three or four inches back from the end. nds are then tapered down so that the area is approximately ı square. A suitable counter sunk depression is then made ive the rivet head at each end of the bar; one may also be on the side of the bar about an inch from the end. This will the use of the same bar in corners as well as on rivets so



350.—Showing Construction of Semi-Elliptic and Three-Quarter Elliptic Springs.

that the length of the bar does not prevent it being held , the rivet heads. Two men are required to do a good job ting, one to manipulate the riveting hammer, the other to ıe bar up against the rivet and absorb the impact of the r. If the frame members are very loose it indicates that the have become reduced in diameter and partially sheared. s of this kind nothing will be gained by peening the rivet

heads over more. The only safe remedy is to chip off the riv with a sharp cold chisel and then knock them out of the ho a steel drift. The holes are then drilled to the next larger s rivet size and new rivets secured. These are usually of iron, and should be heated to a red heat in a gas or co before being headed up.

Care and Repair of Springs and Spring Parts.—The more annoying condition to the motorist who desires a smo ning and quiet car than continual squeaking noises due running gear components. If the springs squeak continuou their complaint does not cease after a thorough oiling of pension joints and shackles, there is no cure other tha ducing lubricant between the leaves. The best method c this is to take the springs apart and place liberal quan graphite grease between the leaves before assembling th remounting. Before commencing operations the chassis sl securely supported and blocked up to take the load off both at the front or rear, as the case may be. A good method (this is to lift the car by jacks and support it from the hangers by a heavy iron bar or wooden beam placed directl them and between the springs and the frame, as shown at F The weight may be taken by a wooden trestle or suitable b Another method is to relieve the weight of the car by rai cross piece with a chain fall or portable crane. When t is taken from them, the springs will assume their natural p and it will be comparatively easy to release the spring clips them in place at the axle and the shackles and take then When reassembling, fill up all of the holes in the shack bolt eyes with grease. While the spring leaves are separate be well to remove all rust from the surfaces by scraping a smoothing with coarse emery cloth.

Various types of springs that have received general app are shown in illustrations Figs. 350 to 353, inclusive. That A, is one of the most popular spring types and is called the elliptic"; the form at B is known as the "three-quarter el A platform spring suspension consisting of two semi-elliptic parallel to the frame side member and one semi-elliptic spri

l to the rear cross member joined together by double shackles hown at Fig. 351. The cantilever form of spring which is now ıming some prominence is shown at Fig. 352. The "full elliptic ing," outlined at Fig. 353, is not as popular as it used to be, is found on cars of several years back rather than on pres- day models. There are two notable exceptions, however, the nklin and the Jackson, which still use the full elliptic con- ction.

It will be observed that there are a number of points about ngs that demand attention besides the spring leaves. These ude the spring supporting shackles, the shackle bolts, the spring

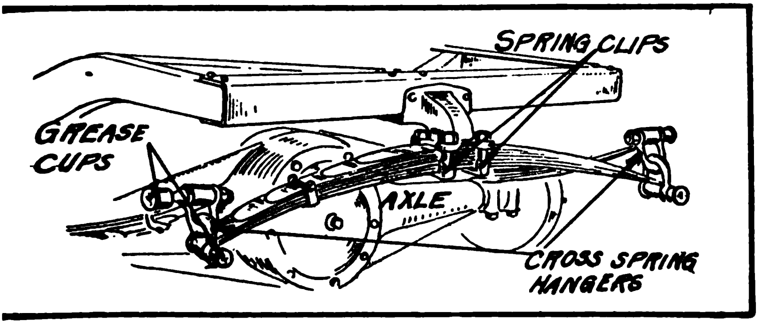


Fig. 351.—Arrangement of Platform Spring Suspension.

ining clips, and the rebound clips. There is considerable di- sity in the design of the spring leaves and the finish at the of each member. The nomenclature of the various finishes mmended by the S. A. E. is clearly illustrated at Fig. 354, A. usual construction of a spring clip is shown at B. The ap- ved type of spring shackle is shown at C. As will be apparent, member consists of two side links and two bolts holding them lace to the spring eyes. On modern cars the bolts are provided small grease cups and with passages drilled through them, ugh which lubricant may be introduced to the bearing surfaces. spring eyes are bushed with bronze bushings, which may be wed easily when worn. On cars several years old this pre-

caution was not taken except on those high grade makes ' cost was such as to warrant the expense. To-day, pract cars, even though selling at moderate prices, are provi this refinement of detail. Where no provision is made

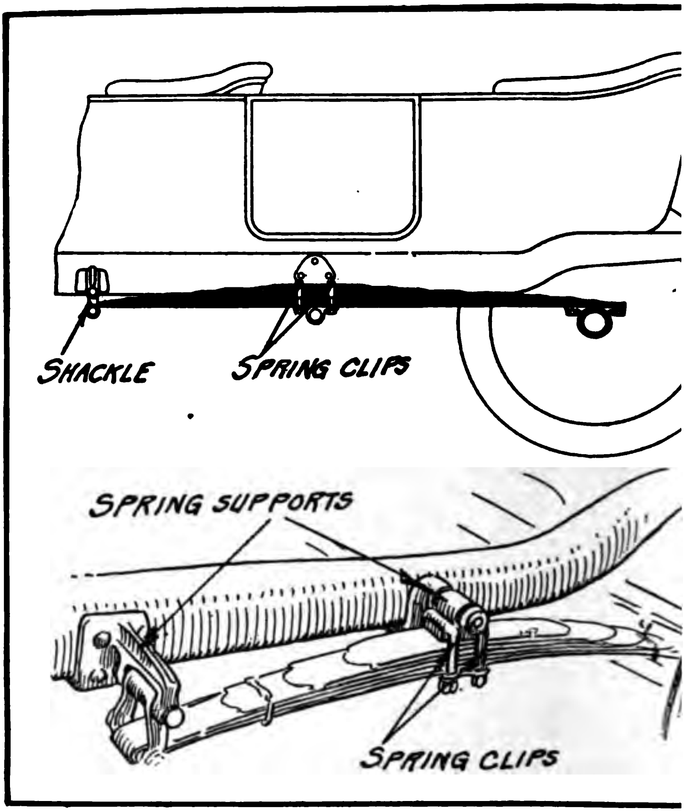
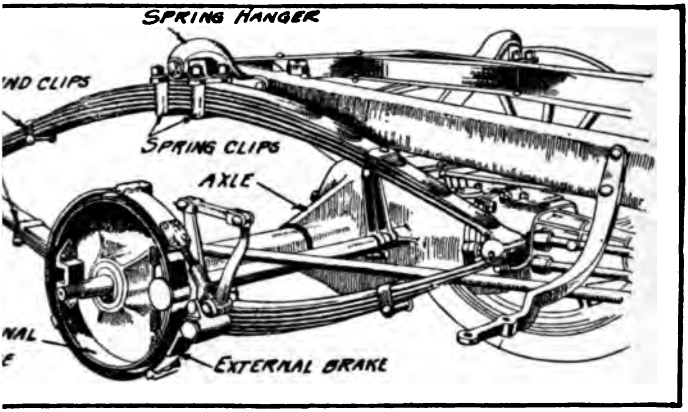


Fig. 352.—Cantilever Spring, as Used on 1915 Automobi

cating the shackle bolt, and where the hard steel spring directly against it, it is not unusual to find these bolts ' way through after a season's use. Even when the bolts ; *lubric*ated type, it will be found advantageous to take

ılly and clean out any hard grease that may have accumu- the passages or between the bolt and the bushings. With ɔonstruction the bolts were usually left soft so as not to spring eye. For this reason they wore rapidly. The only ɪs to replace the worn bolts with new ones of the proper

smounting the springs is considered to be too strenuous raphite and oil may be introduced between the leaves by



—Application of Full Elliptic Springs for Supporting Rear of Automobile Chassis.

ne form of a spring spreader. Block up any lifting jack ʼhen the ram is at the lowest point it can just be intro- tween the blocking and the lower flange of the frame at g hanger supporting the spring first operated upon. If is screwed up until the tire is raised clear of the ground cause the weight of the wheel and a portion of the axle spended from the frame through the spring, and if no clips are provided and the spring retaining clips are slightly, the leaves will probably be easily separated by duction of a spring spreader. The graphite grease may introduced between the leaves with a piece of tin or oil applied with a hand oil cup. A handy device for use

in garages, and one that can be easily made by the repairman, shown at Fig. 355, A. This is easily forged out of soft steel, a if necessary the wedge-shape tips may be case-hardened. T handle should be made of such length that no great amount strength will be needed to spread the springs. The method of t is very simple and is clearly shown beneath the cut of the to Another form of spring spreader which may be procured of a

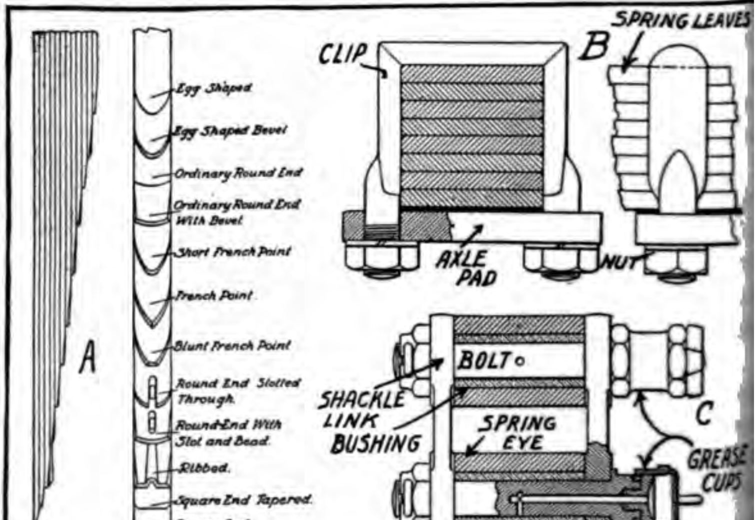


Fig. 354.—A—Defining Designation of Finishes of Spring Leaf End B—Showing Construction of Spring Retaining Clip. C—Section of Spring Shackles Using Lubricated Shackle Bolts.

accessory dealer and the method of use is shown at Fig. 355, This has the advantage of being readily adjustable for differ widths of springs.

A simple device that has been recently introduced for the purpose of feeding lubricant between the leaves of a spring tinually, and just where the lubricant is needed, is shown at F 355, C. This is known as the Dann insert, and is a piece of

exible metal, having machine-punched, staggered holes as shown. hese holes are filled with a special grease having a melting point over 200° Fahr., and on both top and bottom of the metal rip a piece of prepared wax paper is placed to retain the lubri-nt lodged in the holes of the metal strip. The strips are cut to e proper length and placed between each pair of spring leaves. e inserts may be procured in sets, all cut to proper length, for e springs of standard cars. It is stated that after the inserts placed in a spring the rubbing action tends to wear off the x paper and permits the grease to flow between the spring aves. As the grease is retained in pockets, it is not apt to n out at the sides of the leaves and spoil the finish of the r.

The following advice on the care of motor truck springs was ken from a paper read by John G. Utz before the S. A. E., and many of the points mentioned therein apply just as well to the me supporting members of pleasure automobiles, they are re-ned and can be followed to advantage by the motorist and re-irman as well as the motor truck driver.

Keep Clips Tight.—Spring clips should be inspected at least ce a week and tightened as much as possible. If the clips be-me loose, the spring will break between the clips. If there is ue stretching of the clips, the difficulty might be overcome by ing new clips made of better material, as it is always cheaper replace clips which are too light than to have broken springs a result. The bearing place upon which the spring rests on the should absolutely conform to the curvature of the spring at t point, as sufficient bearing surface is just as important as ht spring clips.

Hints on Repairs.—If a spring plate should break, it is im-tant to have it repaired or replaced immediately by a skilled ing maker. Quite often a break in a plate occurs at a place re it does not immediately cripple the entire spring, but it is ple to understand that the breaking of one plate throws extra k upon the other plates which will break in turn. If one of intermediate plates should break at the center bolt, the spring should be tightened down until it is possible to have

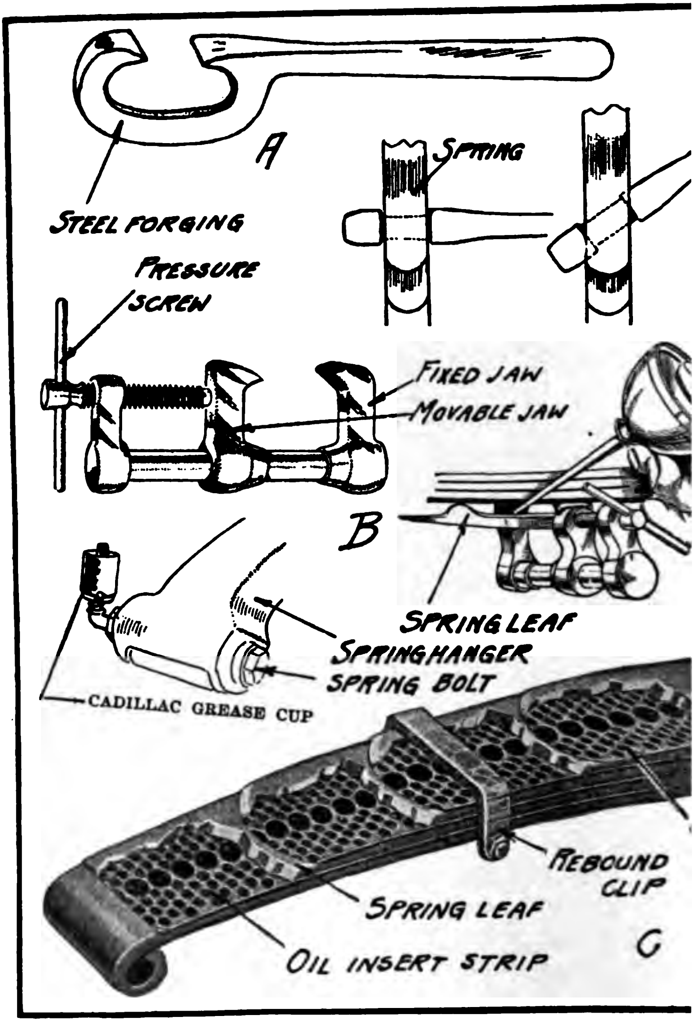


Fig. 355.—Methods of Inserting Lubricant Between Spring]
Prevent Squeaking.

ıe break repaired. Very often rebound clips are loose and roken. Missing rebound clips very often result in broken main lates.

On chain drive trucks there is always an ample allowance for ljustment to offset the stretch and wear of the chains. As the ıains become stretched to a great extent, it is wise to remove an ıtire link and then shorten the adjustment so as to keep the ›ring shackles (at each end of the spring) standing at about the ıme angle.

A spring is a complete unit as produced by the spring maker. he removal or addition of a plate entirely disarranges the grading f the original plates, and should never be practised under any rcumstances. It is also very bad policy to replace a broken plate y any plate that happens to be of the same width as the spring. t is far more desirable to let a competent spring maker attend to ıe repair or replacement.

In view of the preceding, there follows a list of things to be bserved in the operation and care of the truck, if there is a desire › give the springs a fair chance to offer their longest life.

Rules of Reason.—A.—Evenly distribute load. Prevent shift-ıg of load. B.—Do not overload beyond rated capacity. The fac-ır of safety allowed by the maker is for the owner's protection as ell as the maker's. C.—A wheel out of round due to flat spots on solid tire, imposes a severe and dangerous shock upon the springs. eep the wheels round. D.—Keep excessive side play out of ıackles and hangers to minimize the lateral shock on the springs hen on rough roads. F.—Give careful attention to all parts sub-ıct to friction. Keep them amply lubricated, as an excess of grease eeps the dirt out. F.—Take corners slowly, without or with load. .—Back into a curbstone or platform gently as your radius rods ight buckle and throw the jolt upon the springs. In driving the ont wheels against a curb or any obstruction, the shock must be ken by the springs alone. H.—When loaded, drive gently over ıugh road or obstruction, remembering the frame is rigid and the rings must take the distortion. I.—Drive at moderate speeds at l times. Remember solid tires have little resiliency. J.—If you ave to tow a car, or have your car towed, hitch the tow-rope to

the frame, not to the axle. K.—If an accident occurs, and a sj hanger, or the frame near the hanger is bent, have it straigh at once. A spring distorted by a bent hanger is liable to under load. L.—When adjusting chains, remove a link whe adjustment would throw the shackles to a bad angle. M.— spring clips tight at all times. If a center bolt should break to loose clips, replace it at once. N.—On a crowned road, dr nearly in the center as possible, as driving to the right thro extra load on the right-hand spring.

Compensating for Steering Gear Deterioration.—One c most important parts of the chassis assembly and one that s never be overlooked in overhauling is the steering gear, beca is upon this important control element that the safety of the ca passengers depends. The steering gear should always be kep justed to the point where the wheel will turn freely and ye have any back lash. The steering gearing consists of the ste column, the wheel supporting knuckles on the front axle, th bar that joins the steering spindles together and the drag link v acts to transfer the movement of the steering arm to the front members. Typical steering columns are shown at Fig. 356. at A is the most common form and utilizes a worm at the lower of the steering post to which the hand wheel is attached, me with the worm gear which actuates the ball arm. A sectional of the reduction gearing is shown in the inset A-1. The other of gear generally used is known as the thread and nut form has a worm at the lower end of the post which rocks the ste arm sometimes called the "pitman" arm or "ball" arm by m of two half nuts, one of which moves up and the other down the worm is turned by the hand wheel. This reciprocating m of the half nuts is transferred to the pitman arm by an oscill member against which the ends of the half nuts bear and wh attached to the shaft that rocks the steering arm.

Another form of thread and nut steering gear is shown at 357. In this the nut is a full member encircling the screw carrying projecting pins which engage the forked arms attach the steering arm actuator. As will be apparent, when the scr turned by the hand lever, the nut is raised or lowered, depe

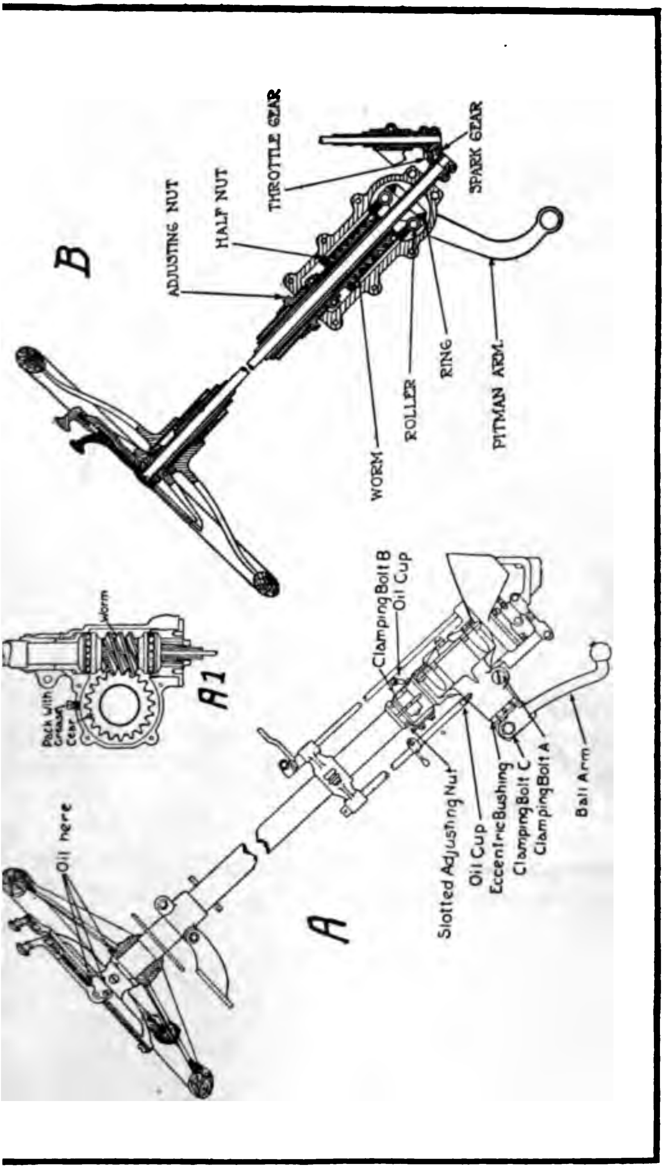


Fig. 356.—Outlining Construction of Typical Steering Gears. A.—Worm and Sector Type. B.—Screw and Nut Pattern.

upon the direction in which the screw is turned. This up ar motion of the nut is transferred to the steering actuator the medium of the small pins working in the forged yokes a to the steering arm actuator shaft. The steering gears d are of the irreversible form, i. e., motion of the road whe not affect the hand wheel. Many other arrangements ha used for steering gears, one of the popular forms being tl pinion and sector arrangement used on Reo automobiles v shown at Fi; The bevel pinio the bevel gear back and forth turned, this mo ing transferred steering arm a on the same s which the bev sector is fast While this gear is effectiv not irreversibl motion of th wheels may m steering wheel.

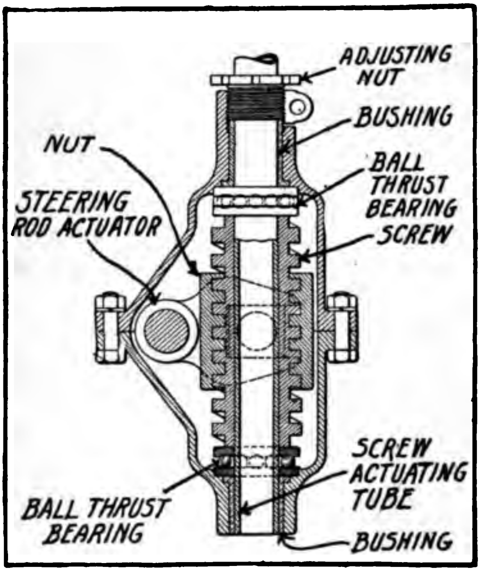


Fig. 357.—Internal Construction of Screw and Nut Reduction Steering Gear.

The commo with a steering any type after been in use for is back lash in duction gear. By this is meant the ability to turn the han back and forth a certain portion of a revolution without e a corresponding movement of the front wheels. There are ber of points where this back lash may exist. It may be in the reduction gear of the steering column itself or may to depreciation or poor adjustment of the various rod ends steering linkage. Considering first the reduction gearing worm and worm gear type, as shown at Fig. 356, the poi

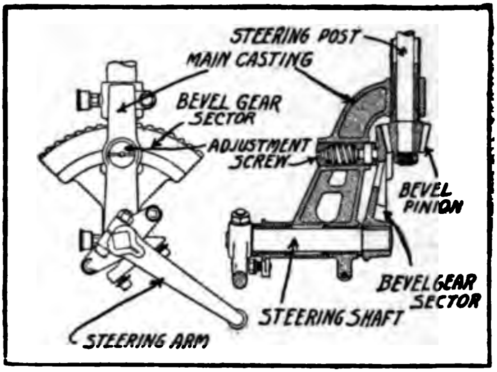
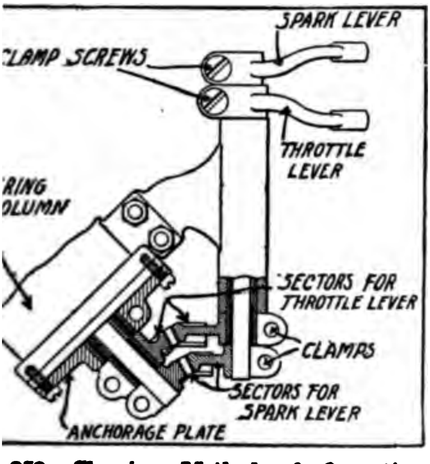


Fig. 358.—The Reo Bevel Pinion and Sector Steering Gear.

wear soonest is portion of the ı gear that meshes the worm when ʼheels are set for ;ht ahead going. reason that this ːciation is present s point more than ıe other teeth of rorm wheel is be- this point is most y used, the move- of the worm be- ery slight except when turning a corner. Attempts are often to take out this back lash by bringing the worm gear into · arrangement with the worm by the use of eccentric bushings ıich the worm wheel shaft is supported. The eccentric bush- erves very well if the back lash is due to poor adjustment r than depreciation of the worm wheel teeth. It is possible on most gears to remove the steering arms, give the steering wheel a half turn and then replace the full worm wheel so the unworn portion opposite to the worn teeth will be brought into engagement with a comparatively unworn portion of the steering worm. The eccentric bushings in this case can be used to secure correct meshing of the worm and worm wheel teeth.



359.—Showing Method of Operating park and Throttle Levers at the Base f the Steering Column.

As considerable end thrust exists at the top and bottom worm when the hand wheel is turned, ball thrust bearings a to resist the end pressure and make the worm easy to oper: these bearings become gummed up with dry grease or if tl or races become roughened, the steering gear will work ha the ball bearings are not properly adjusted, an up and do tion of the steering post will be possible. If the steering loose in the steering gear case it is on account of wear of th bushing in which it turns. These bushings are best repla new ones when worn.

In the type of steering gear shown at Fig. 356, B, the ha are sometimes of babbitt metal and if not properly lubricat deteriorate quickly. The hardened steel screw seldom sho signs of wear and if lost motion exists it is generally due preciation of soft half nuts. The best method of repairin replace these with new members. In the type of steering shown at Fig. 357, the nut is usually made of hard bronze a screw of hardened steel. Very little depreciation will exi gear of this nature unless lubrication has been neglected. are two plain bushings which may wear that support the s post, also two plain bearings on which the steering rod a shaft rocks. Any looseness due to depreciation of the bushin only be eliminated by replacing with new bushings. If t becomes worn it is cheaper to supply a new one than to a to use the old one.

Back lash or lost motion in the bevel gear and sector s gear shown at Fig. 358, when not due to depreciation of th bearings supporting the steering post and steering shaft r compensated for by screwing in on an adjustment screw carries a roll at its lower end, bearing against the back of th gear sector. This tends to keep the pinion and sector teeth tact and eliminates lost motion between them. Practically al ing gears are provided with grease tight casings and sho packed with lubricant at least every season. The plain bear most steering gears may be lubricated through the medium c pression grease cups as shown at Fig. 358, or oil cups as sh Fig. 356, A. If care is taken to supply these bearing point

the proper quantities of lubricant, but little trouble will be experienced due to depreciation of the plain bearing.

Many steering gears have the motor speed control levers carried above the hand wheel by a fixed sector which is supported by a tube passing through the center of the hollow steering post and clamped at its lower end to a non-rotating anchorage plate which keeps the sector from turning, as the hand wheel is moved in steering. Through the center of this anchored tube, another tube passes, in the interior of which is carried a rod as shown at Fig. 360, A. The short control lever is pinned to the rod passing through the center of the steering column while the long control lever which works on the outside of the segment is attached to the tube surrounding the center control rod. At the lower portion of these members a pair of small bevel sectors is carried as shown at Fig. 359. These sectors engage coacting members which operate the spark and throttle levers with which connections are made to the carburetor throttle and to the magneto contact breaker. When dismantling the steering column it is important to take out the center control tubes and remove all the rust that has accumulated between them. They are then smoothed and cleaned with emery cloth and coated with graphite grease before reassembling. In many cases, when movement of the control levers does not produce a corresponding motion of the timer or throttle, it is because the small levers or bevel sectors at the lower portion of the steering column have become loose on their actuating tubes or rods. The usual method of fastening these members is by friction clamps and the trouble is easily remedied by tightening the clamping screws more firmly after the various parts have been located properly. This may be done by setting the control lever at the retard position on the sector and making sure that the magneto contact breaker or timer is also at full retard position. When setting the throttle control lever, that member may be moved down to that portion of the sector corresponding to a closed throttle and making sure that the throttle is closed at the carburetor before tightening the clamping screws at all points. For instance, if the construction of the control levers is as at Fig. 360, A, and the lower portion of the steering post is as at Fig. 359, it will be necessary to tighten four clamp-

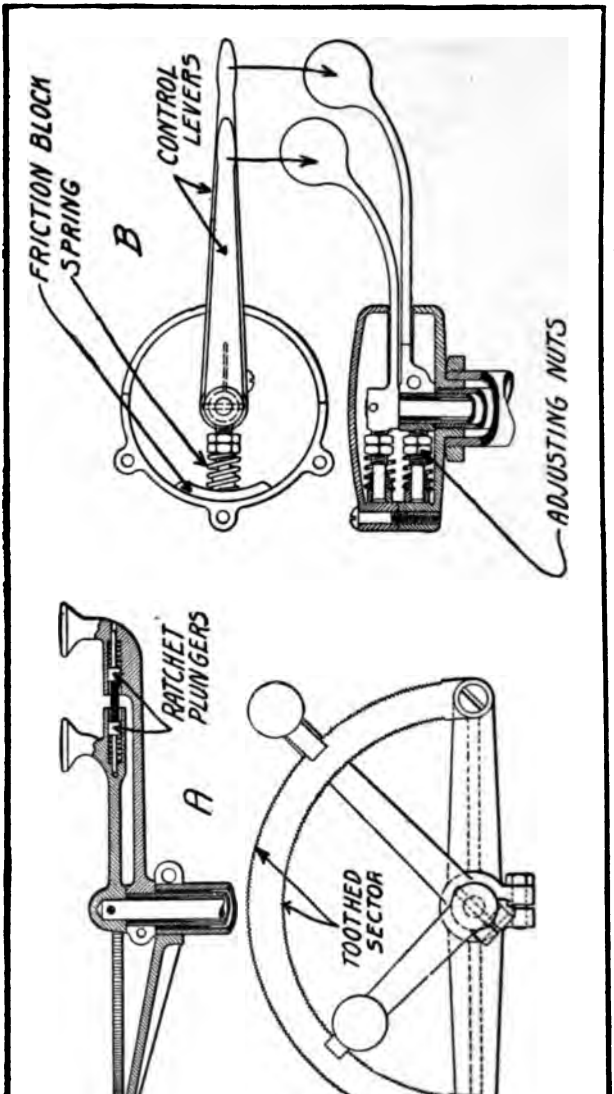


Fig. 360.—Showing Method of Supporting Spark and Throttle Levers at the Top of Steering Column.

; screws in order to lock all parts firmly together. Two of these mping screws are in the small bevel sectors while the others are the levers, one at the bottom of the steering column, the other the top. There may be a tendency at times for the entire toothed ment to turn with the steering wheel which causes the engine race or which shuts it off altogether when turning a corner. This noying condition is due to looseness of the sector supporting tube the anchorage plate at the bottom of the steering column. If ficulty is experienced in keeping this tube tight, the trouble is e to deposits of rust between the sector supporting tube and the erior of the hollow steering column. The only remedy is to re-ve the sector retaining tube from the interior of the steering umn and remove all rust deposits and coat the parts liberally h lubricant before reassembling.

The control levers at the top of the steering column are usually the form at Fig. 360, A, though in some cases the construction own at B is used. After the car has been used for a time the e teeth on the sector may become burred over and the ratchet ingers may be rounded by constant friction with the teeth so the ers no longer stay in the places where they are set. The remedy r this condition is obvious. The teeth in the sector must be recut th a fine, three cornered file and the ends of the ratchet plungers ust be repointed by grinding and the springs keeping them essed against the sector should be strengthened by lengthening. Then the friction block arrangement as shown at Fig. 360, B, is nployed, any tendency to slip may be easily remedied by tighten-ig up the spring tension adjusting nuts shown. The increase in ring strength augments the friction between the friction block d the side of the casing and serves to retard too free movement of e control lever.

A complete steering gear assembly with all parts clearly indi-ted is shown at Fig. 361. This shows the various points where ck lash may exist and the resulting lost motion produce erratic eering. Taking these up in order, we have first the bolts support-g the wheel spindles in the yokes at the end of the axle, and the ishings in the wheel spindle itself. Next we have the pins and d ends at the end of the tie rod, then the connections at ea

end of the drag link. The point where the steering arm to the steering gear should also be inspected to make sure t arm is firmly clamped to its actuating shaft. On practic cars, removable bushings are provided in the steering spindl may be readily removed and replaced with new when wor ends of the tie rod have the bolts in them a tight fit and screw through the lower portion of the rod end. This mea

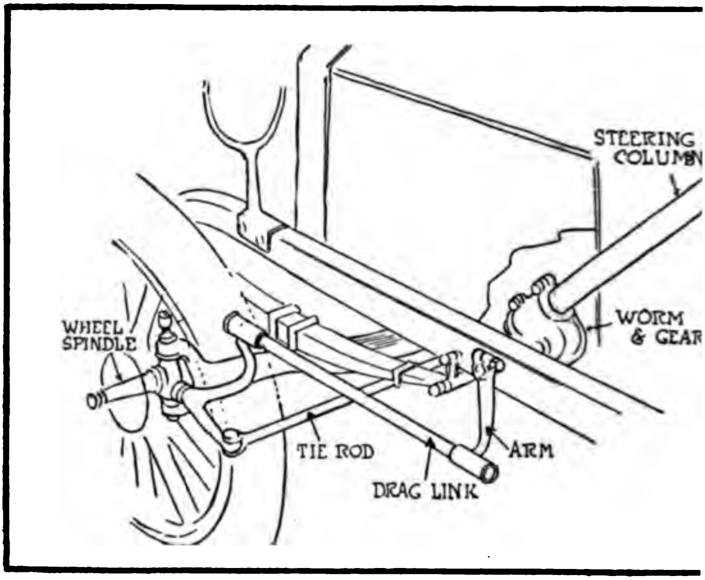


Fig. 361.—Showing Important Linkage of the Steering Syst

the wear will come on the bushing in the steering arm that from the spindle instead of in the rod end.

The various steering gear parts that demand inspect grouped at Fig. 362. The section at A shows a worm an sector steering gear with the upper half of the gear case r to expose the gearing. This form is subject to the same that the full worm gear and worm arrangement previou scribed is, but in event of wear of the sector teeth it is not *to turn* this over and obtain a new set of bearing surfaces.

the only remedy when this construction is followed, is to re- : the sector with a new one. Of course, if the lost motion is to poor adjustment, the usual eccentric bushing method of ;ing the teeth into more intimate contact may be used. The ıgement of the rod ends used on the drag link and designed ›erate in connection with the balls usually provided at the of the steering arm is shown at B. As will be apparent, ›all rests between two plugs having semi-spherical depressions act as a ball seat. One of these plugs is pressed against the by a substantial coil spring, while the other adjusting plug ɔught in contact with the ball with a threaded adjusting plug. ıe ball can only be introduced in the socket when the adjust- ›lug is out, which permits the small section of the steering arm ; the slot, it will be apparent that even if this joint should n that it would be practically impossible for the ball to come In event of lost motion being manifested this may be easily ı up by loosening the clamp bolt or removing a split pin lock times provided and screwing in the adjusting plug until all notion is eliminated.

he usual steering knuckle assembly is shown at Fig. 362, C. ll be observed that the bolt acting as a bearing for the steer- :nuckle and passing through the top and bottom of the steer- 'oke is provided with a grease cup at the upper part in order the joint may be kept thoroughly lubricated. After the front l has been properly adjusted, if it is desired to find if there y looseness in the steering knuckle, the wheel should be grasped ›posite spokes, one at the top, the other at the bottom and with everage thus provided endeavor to shake the knuckle on its orting bolt. If there is any lost motion the bolt should be ved and its bearing surface examined. If it has been cut into reduced in diameter at the bearing points a new bolt should rovided. If the bushings in the steering knuckle are worn should be driven out and new ones supplied.

ome inexperienced repairmen and many motorists are inclined lieve when they first see a "dished" front wheel that the front has sprung and that the construction is faulty. There is a very reason for tilting the wheel as shown at Fig. 362, D. This

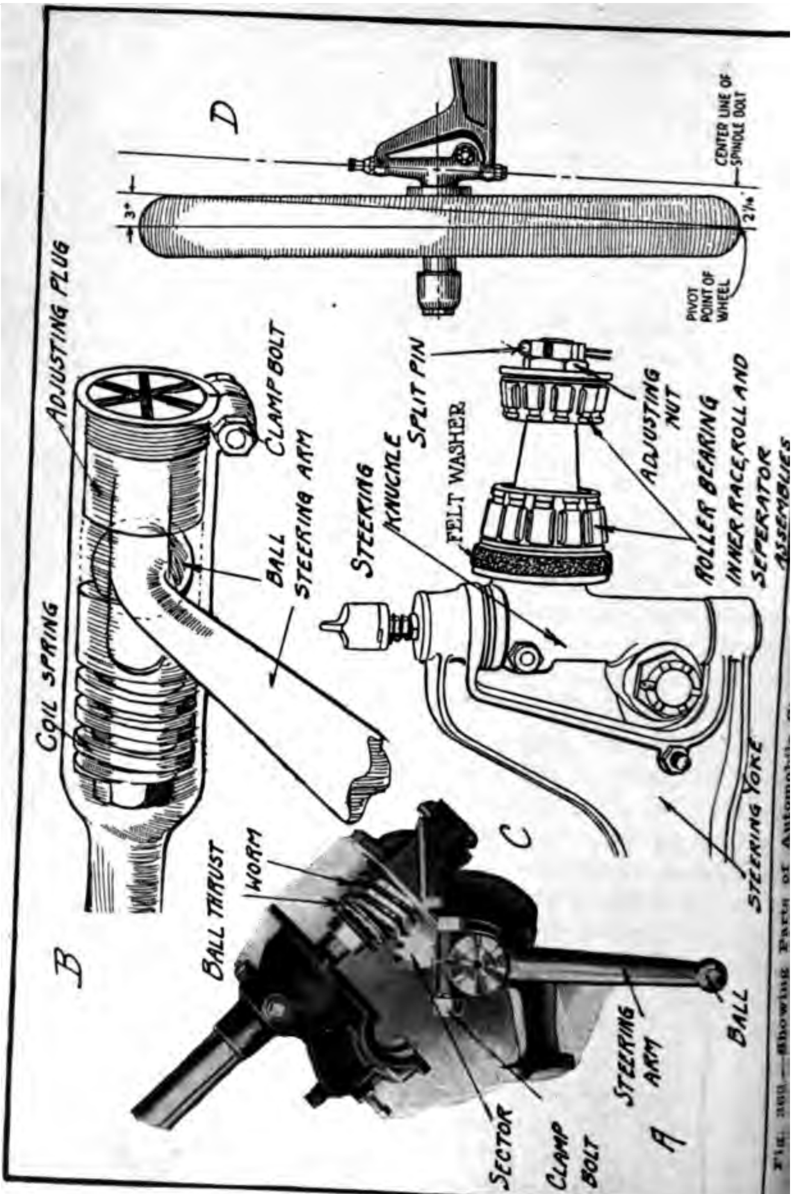


Fig. [illegible].—Showing Parts of Automobile

i to obtain ease in steering and the usual angle of inclination is bout three degrees. Without going into an involved explanation f the reason for doing this it may be stated that it is a mechanical rinciple that the nearer the center of the spindle bolt and the ivot point of the wheel are to an alignment, the easier the car ill steer. If it were possible to bring the center of that part of ie tire which is upon the ground to a point exactly under the oint of the steering knuckle the arrangement would be ideal. To ecure this alignment or to get as near to it as is practical with ie accepted Elliot steering knuckle construction, it is customary tilt the wheel. In the case of the Ford car, a plumb line dropped rough the spindle bolt would strike the ground about two inches rom the pivot point where the wheel tire rests on the ground. The iagram makes this point clear. It is customary to find the front heels of large cars dished in the same manner so this point should ot be confused with lack of alignment in a horizontal plane hich will interfere with correct steering and result in rapid tire rear.

Testing Wheel Alignment.—A splendid opportunity is present uring the overhauling period for aligning the wheels and axles hich should be done to make sure that they have not moved out f their correct position. But little apparatus is needed to make ese trials, the outfit consisting of two chairs, two heavy pieces of ood, and two lengths of stout cord. One chair is placed at the ar of the chassis, the other at the front as indicated at Fig. 363. he chairs are located as near as possible to the center line of the achine and after the cords have been adjusted the chairs are read apart enough to tighten the cords. In order to prevent ovement of the chairs when they have been properly placed they ay be weighted down with iron or steel parts. The important ing to do is to have the cords parallel to the frame side member d to have the member on the right just the same distance away om the right hand frame rail as the left hand cord is from the ft hand frame rail. A common defect of alignment of the front heels is shown at A. In this case the tie bar is too short and the heels are nearer together at the back than they are at the front. he opposite to this condition is shown at B, in which case the tie

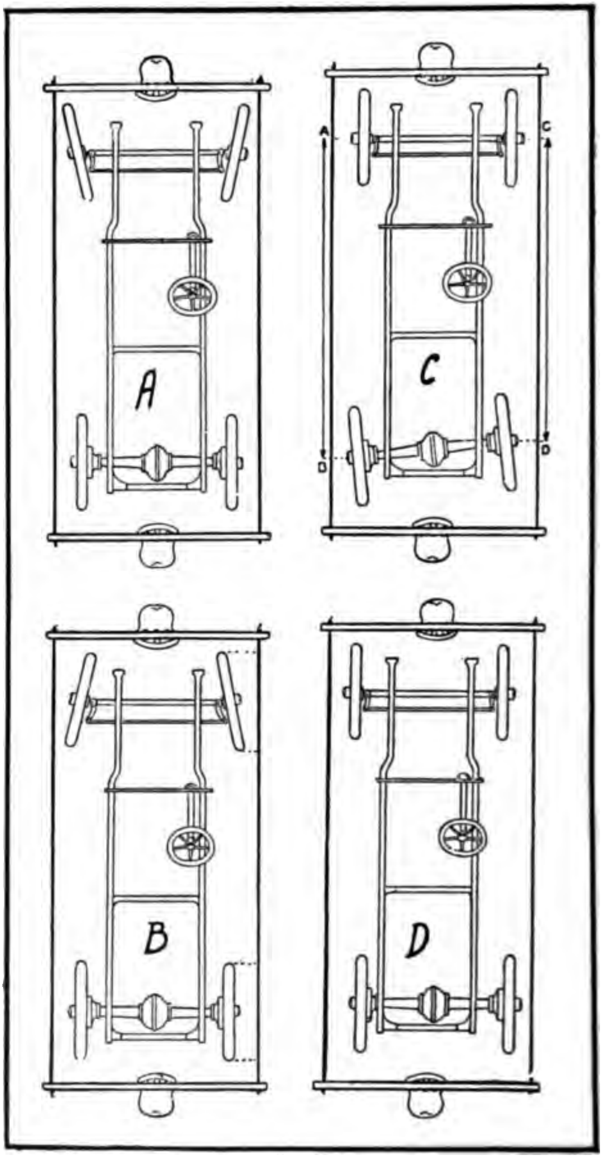


Fig. 363.—Methods of Lining Up Front and Rear Wheels.

ɔar member is too long and the wheels are nearer together at the front than at the rear. Either of these conditions will result in ıncertain steering and will also produce rapid tire depreciation. Practically all tie bars are adjustable to a degree and steps may be aken to straighten up the wheels by either lengthening or shortenng the tie bar as conditions demand. The sketch D also shows the nethod of testing a rear wheel for parallelism with the frame side nember. At C, the method of measuring for alignment of front ınd rear axles is shown. As will be apparent the rear axle has hifted on its springs and the wheels are not parallel with the rame side members. At D, the axle has moved sideways due to hifting of the spring chairs and the wheels do not track, even hough the rear wheels are parallel to the frame side member. It s important that the cords be stretched at a height equivalent to he center of the wheel hubs because some cars are made with considerable gather in the front wheels so that the distance at the ear of these members to the cords would be slightly less than at he front. Then again, many cars have considerable camber in he front wheels which means that the top of the wheels will lean utward, therefore any distances measured above the center of the ub will not agree with those taken below it. By stretching he cord along the center line of the wheel this trouble may be voided.

Universal Joints.—The universal joint is an important element n practically all shaft drive cars, some constructions using but one oint if the propeller shaft is protected by a long housing while ther systems employ two universal joints, one at each end of an xposed propeller shaft. Universal joints on many early cars were un exposed and considerable trouble was experienced due to rapid ear of the bearing parts. When exposed there was also considerble difficulty in keeping the joints properly lubricated. The modm forms are housed inside of a casing member, which is not only signed to exclude the dirt and grit from the bearing surfaces, but hich is also depended on to retain lubricant. A typical universal int assembly and the parts comprising it are shown at Fig. 364, . The main parts of the joint are the yoke member A, and the e member B. The yoke has bearing surfaces O and P designe

to engage two of the pins on the universal joint cross men
The other two pins fit into the bearing members R and S at
to the disc B. The entire joint is housed in by the cover m

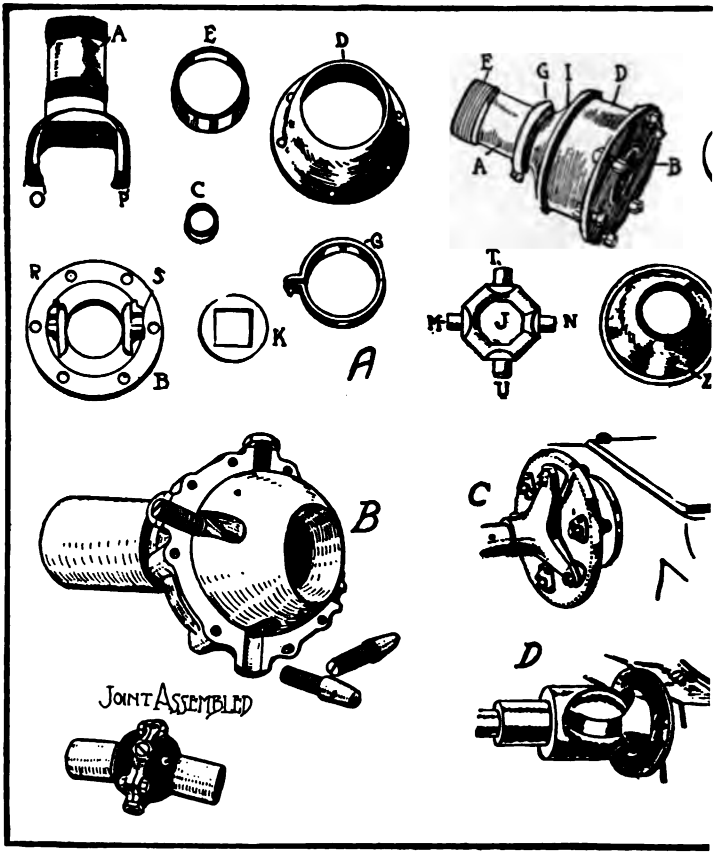


Fig. 364.—Universal Joint Construction.

D and Z. The driving flange B may be bolted to a corresp
member on the end of a change speed gear shaft or rear axle
drive shaft, while the sleeve member A, which is provide
either a square or splined hole as desired, fits on the end

ropeller shaft. The points that will wear soonest are the pins M, N, U, carried on the universal joint cross J. When looking over iversal joints it is well to make sure that the sliding points are ree and that the sleeve member does not bind on the propeller aft. Where two universal joints are used it is not necessary have a slip joint at both ends and one of the sleeve members ay be fastened securely to the propeller shaft.

The universal joint at Fig. 364, B, is called a roller bearing int and consists of a hollow, slit bronze sphere attached to one aft and a steel sphere, which may also be hollowed, attached to formed integral with the end of another shaft. Four adjustle studs carrying conical rollers at their inner ends are equally aced around the outside sphere. The inside ball contains four ots into which the pins project. The slots are so shaped as to low free universal action and get no back lash at any point.

Another form of joint designed to give a flexible drive is shown C. This is increasing in popularity and is found on a number cars for final drive though it is more widely applied as a driving nnection between the clutch or gear box or for magneto or elecic starting generator drive. Two three fingered spiders having suitable boss attached thereto to receive the end of the driving aft are bolted to discs of leather, the fingers of one spider memr being placed between those of the other and the leather disc curely held to each of the spiders. Owing to the flexibility of the ather it is possible to drive parts that are not in absolute alignnt, though this form of joint is not suitable for use where there apt to be considerable movement between the parts and the her types of universal joint are better adapted owing to alwing a greater degree of motion between driven and driving afts.

A simple universal that has been adapted to some extent for ht work is shown at Fig. 364, D. This consists of a ball shaped nter member having machined slots into which suitably formed ke members fit. This joint, while popular for machine tools, is widely used in automobiles and it is illustrated in order that repairman may be familiar with all practical forms of joints. form shown at Fig. 365, A, is that used on the National auto-

mobiles and as two views are presented its construction should l easily understood. A driving member is keyed to the end of t transmission shaft and is securely held on the taper by a suital clamping nut. The driving member is provided with two lon tudinal slots in which square nuts or sliding blocks fit. These a mounted on a pin which is driven through the enlarged end of t propeller shaft. With this construction two joints are necessa

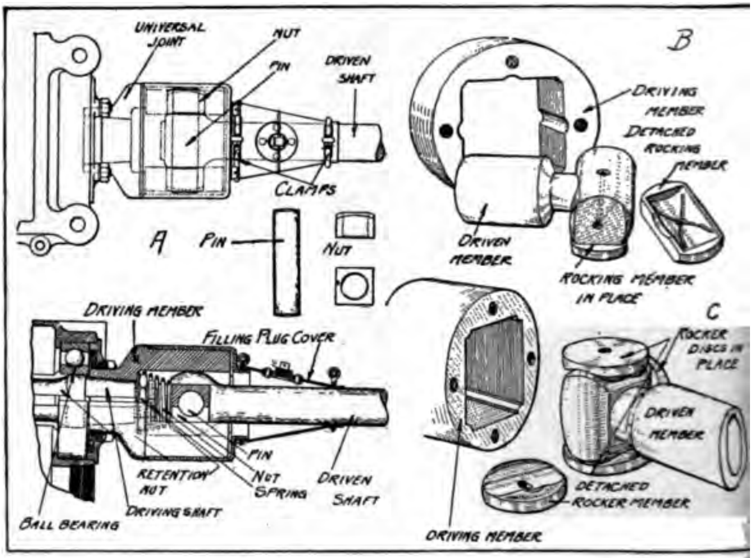


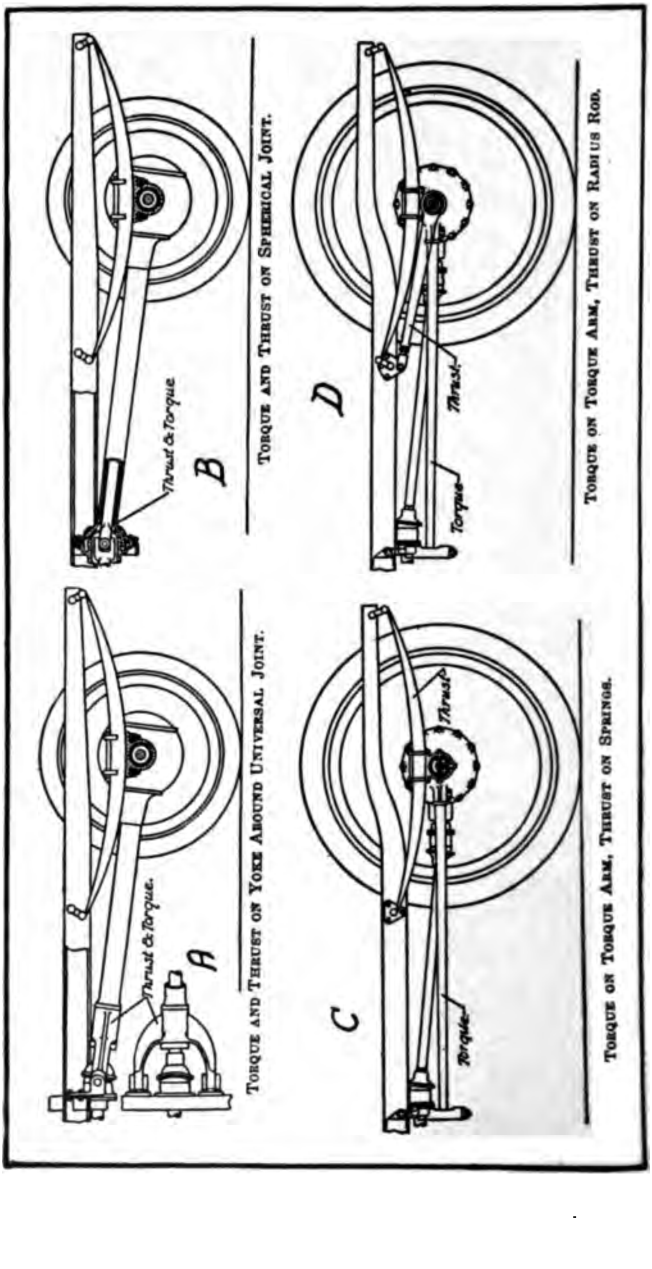
Fig. 365.—Construction of the Sliding Block Pattern Universal Joint

one at the front end of the shaft, next to the gearbox, and anoth on the rear axle. After the joint has been in use for a time the may exist considerable looseness between the bearing pin and t hole in the sliding block and there may also be some depreciati of the slots in which the block slides. If the slots in the drivi member are worn they should be machined out so that they a true and smooth though perhaps somewhat wider than they we originally. It is a very simple matter to make new case harden blocks that will fit the enlarged slots in the driving member. T

anner of covering the joints in order to retain lubricant and keep it the dirt is clearly shown in the illustration. A pressed steel ver member is designed to fit over the driving yoke while the ropeller shaft end is encased with a flexible leather cover securely amped to both driven shaft and flange on driving member cover. order to make it easy to introduce new lubricant to the interior the joints a screw plug is provided which is screwed into a fiting riveted to the leather covering. Where two of these joints e used it is desirable to have the propeller shaft held so it may ide to some extent as the axle moves up and down yet not be loose ough to rattle. The desired end is easily obtained by interposing il springs in each universal joint which bear against the enrged end of the driven shaft and seat on the driving member tention nut.

Other forms of joints which provide a certain amount of unirsal action are shown at B and C, Fig. 365. In the former there e but two rocking members whereas in the latter there are four cking members. The driving member of the joint consists of a eeve having a square hole made to receive the end of the driven ember which is a square or rectangular in cross section but havg rounded faces as indicated. In the form at B, two of the sides this "square ball" are in contact with thin discs having one e curved to fit the inside member and the other side flat to fit side of the internal square. In the form shown at C, four of the cker members are used instead of two. These rocker members not interfere with the universal action and are valuable in that ey provide for longer life than the ordinary form of wabble joint there is ample contact surface between the driving member and face of the rocker discs and there is also ample surface contact tween the driven member and the rounded seats of the rocker cs.

Radius Rods, Torque Members and Control Linkage.—On ry chassis there are a number of points where the motion is relaely slight but where the parts are subjected to considerable prese. Among these may be mentioned the radius rods used with chain drive cars and the torque members furnished when the l or worm drive axles are used. The form of the torque mem-



A. Torque and Thrust on Yoke Around Universal Joint.

B. Torque and Thrust on Spherical Joint.

C. Torque on Torque Arm, Thrust on Springs.

D. Torque on Torque Arm, Thrust on Radius Rod.

Fig. 366.—Conventional Method of Taking Driving Thrust and Braking and Driving Torque in Modern Automobiles.

varies with the system of drive employed and is in turn, de- dent upon the preferences of the designer. The reason it is ssary to provide a torque member with a shaft drive axle is all the time the rear wheels are propelling the vehicle the re- on tends to turn the axle housing and this motion must be re- d by some arrangement that will hold the axle in its proper tion. The torque members are also required when the brakes applied to a car because there is also a tendency for the axle otate when the retarding force is applied to stop the wheels n turning. The various common forms of torque members are vn at Fig. 366, these illustrations having been reproduced from Horseless Age.

The construction shown at A is a common one and is used on mber of cars, some of which, as the Overland, are sold in very e quantities. In this construction, the propeller shaft to which bevel driving pinion is secured is carried by a long tube securely ened to the axle at one end and carrying a yoke casting at the r supported by suitable bearings attached to the frame cross ber. This yoke is mounted so it swivels on the axle tube, per- ing the axle to be higher on one side than the other without sing the joint, a condition that is often necessary and, in fact, voidable when running over rough roads. It is evident that rear axle is also subjected to an up and down motion, this being to roughness of the road surfaces. In order to provide for this ement the yoke casting is hinged to the frame cross members. n this construction is followed there are three points where eciation can exist. The points that will wear soonest are the orting pins or bolts at the ends of the yoke member that fit frame. These may wear enough so that there will be appreci- lost motion, which means a rattling sound when the car is ated over any but the smoothest of roads. The remedy for condition is a simple one, consisting only of replacing the pins and bushings in the yoke ends, if the construction per- or of reaming out the holes larger and fitting pins to corre- d. The joint where the yoke swivels on the torque tube is lly of larger size and is provided with a generous grease cup. e it is not apt to wear as quickly as the joints of lesser area,

if lubrication has been neglected, it may be found that th
will fit the housing tube loosely. The remedy is to smooth d
end of the housing tube after the joint is removed in orde
cure a round bearing and then to bore out the worn yoke a
it with bronze or cast iron so that it will be a good fit on th
ing tube. Any end play that may exist can be readily ta
by putting a light steel washer or a series of these members
the thrust collar on the housing tube and the yoke casti

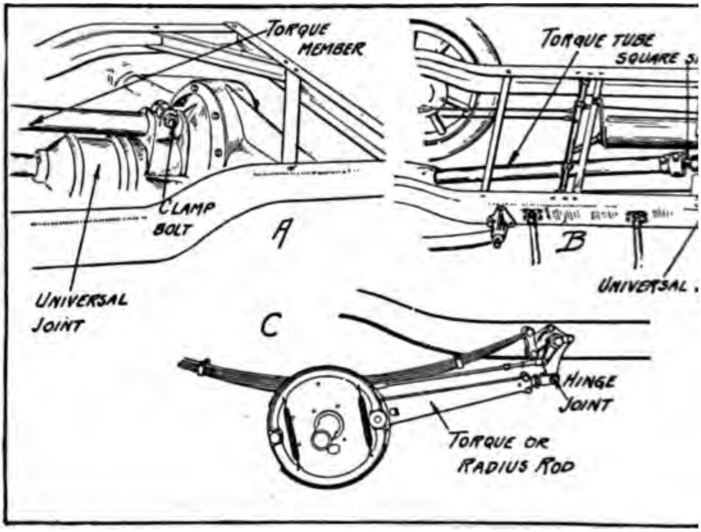


Fig. 367.—Defining Various Forms of Torque Members and Radi

some cars it is possible to compensate for any end motion
ting up an adjusting nut that keeps the yoke in place.

In the system shown at Fig. 366, B, the push or thrus
sary to move the car, also the torque, is taken on a spherica
joint. This construction is used on the Ford automobile a
number of other more expensive cars. Despite the severe w
type of joint is called upon to perform, it is not subject t
depreciation, providing that lubrication is not neglected a
proper precautions are taken to keep the grit and dirt in

use from accumulating between the bearing surfaces. If there any play in this form of joint it often can be compensated for by king a little metal off the face of the flange of the ball joint p which permits of bringing it to bear more tightly against the ll on the end of the torque tube.

The system outlined at C is a popular one on many types of rs. In this the driving thrust is taken by the semi-elliptic springs, hile the torque is resisted by a special lever securely clamped to e differential housing of the axle at its back end and carrying small ball end which is suspended in a special shock absorbing ture carried by the frame cross member. This form is sometimes odified by having short radius rods to take the driving thrust shown at D, while the braking and driving torque is resisted by special arm. The flexibility of the special hangers used for suprting the front end of the torque rod shown at C and B, is due the use of strong coil springs which press against pads having ni-spherical seats to fit the ball at the end of the torque rod. If se springs weaken in use, there may be a certain amount of lost otion between the ball and its seating members which can inriably be corrected by screwing in an adjusting plug carried at e bottom of the tubular spring housing. When radius rods are ployed, it is important to test these for side shake when they are pported by the axle or to test the small pins when they are card by a hinged member secured to the axle and often forming rt of the spring pad or seat. Owing to the limited area of the ns that act as hinges at both ends of the radius rods it is not usual to have these wear enough in a season to demand inspecn and attention.

The method of supporting the axle end of a tubular torque mber when a two universal joint propeller shaft is used is clearly own at Fig. 367, A, as will be observed, a retaining member is t integral with the bevel pinion supporting casting. The tubu- torque member is a tight fit in the hole bored into this support l is held firmly in place by tightening the clamp bolts indicated. en overhauling a car it is well to examine this clamping bolt efully to make sure that the torque rod is securely held. In cars, where the driving thrust is taken by the springs the

torque is taken by the universal joint. A construction of th is shown at Fig. 323, B. The usual construction is to have a shaft projecting from the torque tube sufficiently long so it the full length of the hub of the universal joint. Up anc movement of the rear axle is compensated for by the sliding

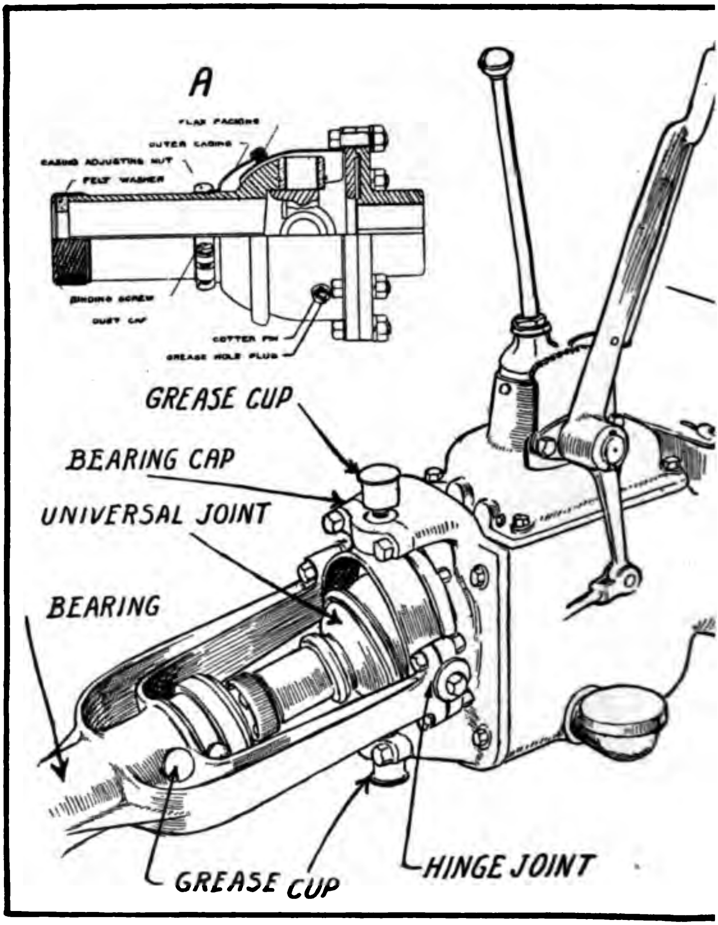


Fig. 368.—Method of Suspending Torque Tube on 1915 Buic Automobiles.

uare shaft in the universal joint. This is a point that is very ten neglected as regards lubrication, usually because it is inac- sible in most cars. If the square shaft becomes worn there will considerable lost motion between it and the universal joint. It often possible to secure a new universal joint member having a aller square, and as the wear is seldom more than .010 inch it is ten possible to save the old shaft by the less expensive procedure replacing the universal joint member rather than taking the tire rear construction apart to use a new squared shaft. If the iversal joint member is a steel drop forging it is possible to heat up in a forge or brazing flame and then close it down around a uare bar of the desired size. The worn end of the square shaft y be dressed down to fit the corresponding portion of the uni- rsal joint member. When overhauling a car in which a torque be is used care should be taken to inspect the point where the rque tube joins the rear axle differential housing to insure that rivets are tight and there is no motion between the torque tube d its retaining member.

The bearings at the front end of the torque tube are found to subject to more rapid wear when this construction is followed n when any one of the systems shown at Fig. 366 is used. If ad- stment means are provided the bearing depreciation may be taken re of by tightening up the adjustments. If, however, a plain bbitt bearing or bronze bushing is used it will be necessary to re- ce the defective member with a new one. The end of the torque be is often provided with a straight roller bearing. If there is ch play, the bearing should be examined to see whether the lls are worn or if the lost motion is due to depreciation of the ving shaft or the roller bearing shell member carried by the que tube.

The usual arrangement of a radius rod, which may sometimes arranged in such a way that it takes torque as well as driving ust is shown at Fig. 367, C. The hinged joint where deprecia- n can be looked for when overhauling the car is clearly indi- d in this illustration. On the Buick 1915 automobiles the end he torque tube is attached to the gearset in a novel and effec- manner. In addition to the usual swinging joint between the

yoke member and the end of the torque tube which takes care the up and down motion of the wheels, the ends of the yokes fastened to a ring member having four bearings equidistant spaced at Fig. 368. Two of these bearings on a horizontal plane are used as a support or hinged joint to permit of up and down movement of the axle. Swaying from side to side is taken care by the method of supporting the ring at the top and bottom substantial cast arms, extending from the back end of the gear It will be apparent with this construction that depreciation of the supporting pins of the ring may be compensated for to some tent by removing the bearing caps and filing a little off of the faces to permit them to be brought closer to the pins. Of course it will be necessary to drill the holes out round and ream them the proper size because the process of compensating for wear tend to make the holes elliptical, instead of round.

The construction of the universal joint used with this method installation is clearly shown at the inset A which shows the joint in part section. In addition to the torque and radius rods, all the various members, such as rod ends on the brake rods and control linkage should be looked over with a view of determining any wear exists at the bearing pins. As no provision is made adjustment at these points the only remedy is to drill the holes larger in both the rod end and its supporting yoke and supply new pins of larger diameter that will fit the holes without motion.

Front Wheel Adjustment.—When cup and cone type ball taper roller bearings are employed, it is necessary to adjust very carefully to compensate for any lost motion that may exist the assembly. The condition of the bearings may be ascertained without difficulty when these are used in the wheels by jacking under the axle to relieve the wheel of the car weight and then grasping the wheel rim at opposite points and shaking the Any looseness in the bearings can be detected by the lost motion between wheel hub and spindle. In taking up lost motion any type of adjustable bearing is employed, considerable judgment must be exercised in screwing up on the adjusting member get this up too tightly and impose an injurious end pressure

lls or rollers (Fig. 369). An excess pressure that will stress :aring parts dangerously will not make much difference in heel resistance when turned by hand, though when the car ; must be sustained at high speeds or when going around 's, the resistance e increased ma-y and bearing ınce •reduced in :tion. A safe › follow is to take : wear by screw- the adjustment n o u g h so the e'' or looseness : eliminated and :rmit the wheel pin'' for a few tions when given tial i m p u l s e. motorists and in-

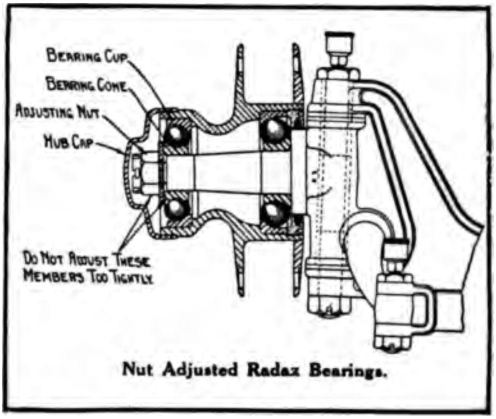


Fig. 369.—Front Hub Showing Nut Adjusted Cup and Cone Type Ball Bearing.

:nced mechanics commit the error of adjusting bearings of ake up'' type too loosely. This is not desirable, any more itting parts too closely together is. Always lock the adjust-nut firmly in place when proper adjustment has been d.

ıffler Faults.—A part of the chassis that is often overlooked overhauling and one that has material influence on the power , of the motor is the device used for muffling the sound of the ıt. The internal construction of mufflers varies widely, some ing only of simple chambers connected together to form a ıth for the gas passage and reduce the noise by breaking up lume and allowing the gas to expand before it reaches the more complicated forms having a large number of baffle or partition walls pierced with numerous small holes. The ffective and silent type of muffler is generally the one that ive trouble first. It is important, therefore, to take the · apart and clean out all accumulations of soot or burnt oil

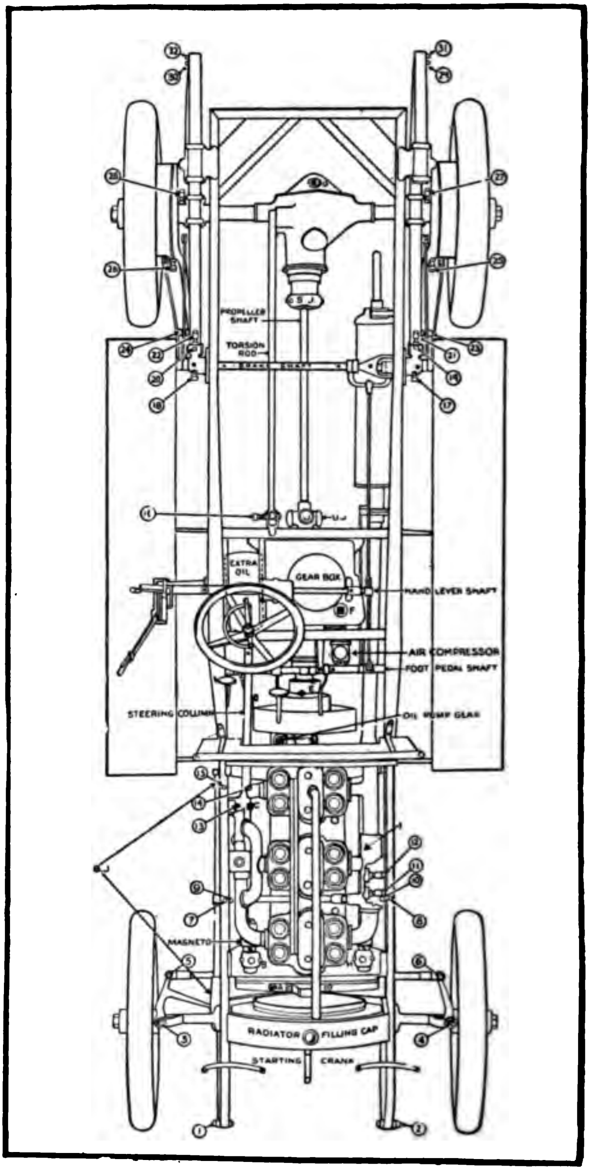


Fig. 370.—Diagram of Locomobile Chassis, Showing Points Dem Lubrication.

may clog up the gas passages. Mufflers are easily taken apart, illy being held together by long through bolts in those forms re the muffler consists of a number of cylindrical shells of vary- diameter held between cast end plates used to support the l. Even in forms where a large number of chambers are pro- d, these being adjacent, the muffler is held together by bolts or eing assembled on a central member usually a continuation he exhaust pipe. After the muffler is taken apart all carbon burnt oil residue should be scraped off and all the parts of the ler thoroughly cleaned with kerosene before reassembling. It so well to go over all the holes designed to break up the gas a sharp punch or fine taper reamer to make sure that these not been reduced to less diameter than they should be by ac- ulations of burnt oil or carbon.

hassis Lubrication.—A very important point that is some- s overlooked after a car has been overhauled is proper lubri- n of the chassis. A typical six cylinder chassis of the Loco- le design is outlined at Fig. 370, with all points needing lubri- n clearly outlined. Practically all of the chassis parts are lu- ited through the medium of grease cups which are indicated circle with the numbers in it, the numbers ranging from 1 to iclusive, beginning at the bottom of the diagram and running ie top. It is important to go over all the grease cups when a iis has been overhauled and make sure that they are filled with od grade of grease of suitable density which must resist the n of water and contain no acid. Grease cups Nos. 3, 4, 5, 6, 2, 27, and 28 are very important and should receive attention r day that the car is in use. Graphite grease is recommended hese points. In addition to the grease cups there are a num- f oiling plugs which are indicated at black squares and a let- Beginning at the bottom of the diagram, oil plug A should moved to supply oil to the timing gear. It is said that one and ialf pints of oil are necessary every 500 miles. The magneto coupling B should be filled with grease. C is the plug through i grease is introduced to the steering worm gear case. New e should be supplied when overhauling, then the operator d be cautioned to replenish the supply every 100 miles. D,

indicates the oil opening for filling the oil pump gear casing grease.

The disc clutch housing is provided with oil plug E. makers of the car illustrated recommend that this plug be rei at the end of every 1,500 miles and the clutch case turned until the old oil runs out. The interior of the clutch casing s then be washed carefully with gasoline and refilled with new cant. This may be a mixture of one-fourth pint of spindle o one-fourth pint of kerosene or a mixture of one-third pint of sene and one-sixth pint of three-in-one oil. It is stated that proportions and quantities are important. The transmissioi case is filled through oil plug F. The gear case should be cated with some good quality non-acid grease of about th sistency of vaseline. It is stated that 20½ lbs. of grease are i to refill an empty transmission case after overhauling. The gear housing at the rear axle is provided with a plug G, tl which grease can be introduced to lubricate the bevel drive ing. It is recommended that this be thoroughly washed ou ing the overhauling process even if the rear axle is not apart. It takes one quart of grease to fill this housing proper point. The oil plugs H and I indicate minor driving lings, which do not require attention very often, inasmuch makers advise filling with grease every 5000 miles. It necessary to keep the interior of the wheel hubs filled with s grease.

Among the minor points that need lubrication are the fa ings, which may be packed with gear grease at the time yearly overhauling. There are a number of minor points inc by round black dots that are oiled with a hand oil can or s by means of oil cups and oil holes. The most important oi are as follows: Starting crank, oil every week. Magneto, few every 2000 to 2500 miles. Foot pedal shaft bearings, oil coj every month. Steering column, squirt plenty of oil throu hole in the steering column every week. Oil also the fixe of the spark and gas lever. Hand lever shaft bearings, lul every week. Brake shaft bearings, oil about every 2000 Dynamo bearings, forty drops every 100 miles. Steering uni

ndicated by the letters B, J, remove the leather boots and th good graphite grease every 1000 miles. The universal ı the propeller ;hich are indi- · the letters U J ', should be in- cleaned and d with grease ›nce a season. ould be taken sure that the ›lant also has per grade and ' of lubricant he car is per- to leave the Most cars em-

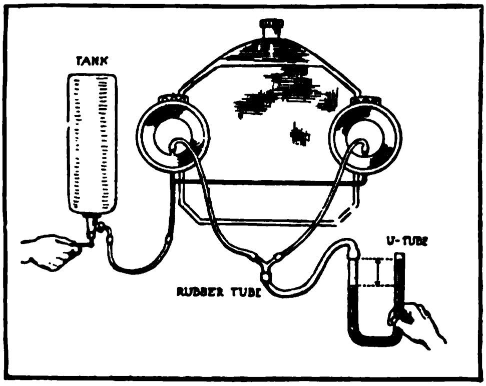


Fig. 371.—Method of Testing Acetylene Gas Piping for Leakage.

stant level splash systems, which have been previously de- the only precaution is to make sure that the oil is at the level in the engine crank case. The strainer screen that ıe oil before it goes into the pump should be cleaned every d it is recommended that after 1000 miles road service that ›il be drained out of the engine base.

ting Acetylene Gas Leak.—Before the general adoption ic lighting practically all automobiles were supplied with e gas burning head lights, the gas supply being from a car- erator, Prest-o-lite or similar tank. In many cases trouble ienced through leakage of the gas which escapes from mi- ks in the gas line, which usually consists of copper tubes in the frame channel and connected to the gas tank and ith flexible rubber tubes. While the overhauling process carried on, it is well to test the pipe lines to see if there leaks in order to replace the copper tubes with new ones hey have chafed from contact with a frame member or › or if a seam has opened up with vibration. A very sim- ıod of determining whether there is a leak or not shown !71, was described in the Automobile. The apparatus con-

sists of three pieces of rubber tubing, a three way pipe conne and a glass U tube. The burners of the acetylene lights ar moved and the ends of the rubber tubes are placed over the jecting pipes as shown in the illustration. The valve on th tank should be closed while this is being done. Water is now p in the U tube but not enough to completely fill it. The needle on the gas tank is slowly opened until the water in one arm (U tube is lifted higher than that in the other because of th pressure. The valve is then closed and the water level in tube watched. If water drops to the same level in both bra there is a leak. A leak may be found by going over all the with oil or a thick soap-suds solution, taking especial care to those portions of the pipes that are resting against the frame bers and also all the soldered joints. The escaping gas will the soapy solution or the oil to bubble at the point where it es

CHAPTER IX

THE REAR AXLE AND DRIVING SYSTEM

Rear Axle Nomenclature—Semi-Floating Axles—Three-Quarter Floati —Full Floating Types—Taking Rear Axle Apart—Adjusting Be Gears—Worm and Spiral Bevel Drive Gears—Two-Speed Axles Reduction Axles—Internal Gear Drive—Four Wheel Drive—S Bevel Gear Differential—Chain Drive Troubles—Trussing We Housings—Axle Lubrication—Oil Retaining Means—Types of A ings—Care and Adjustment of Axle Bearings—Brake Forms justment.

OWING to the advances that have been made in metallu a more general appreciation of principles of design by en the rear axle is a part of the car that seldom gives trou which usually needs attention only when the car is thorough hauled. Very few motor car manufacturers build their o axles and most of those used are the product of speciali make nothing but front and rear axles. The result of t centration upon one product means that the various details portion of parts have received careful attention which h based on a wide experience. The material best adapted various parts have been carefully determined and practic only condition that interferes with proper rear axle operati ring occasional accidents, are those due to natural wear. describing the method of taking down rear axles it may for the reader to become familiar with the different axle ty their method of construction. The designs used vary wide some types it is possible to get at all the essential parts in tively short time without removing the rear construction f chassis. In other forms it is necessary to take them com apart before access may be had to the differential gears axle shafts and their supporting bearings.

Rear Axle Nomenclature.—The various types of axles have been used in automobile construction as defined by the (engineer of the Weston-Mott Company, one of the largest manufacturers in the world, are illustrated at Fig. 372. shows the four main classes of axles, which are termed semi-f ing, three-quarter, seven-eighths and full floating types, these t designated by the letters A, B, C, D, respectively. While the i trations are self explanatory to one well versed in automobile struction it may be well to describe the various types in detai the benefit of those who have not had occasion to take all various types apart. On the semi-floating axle, as shown at A entire weight of the car comes upon the axle shafts which als depended on to transmit the power from the differential gea to the wheel hubs. It is said that in time this would have a dency to cause the shafts to crystallize and break unless great is taken in proportioning the shafts so strong that they will r the stresses imposed upon them. This type of axle is not gene recognized as the semi-floating form as most engineers call non-floating live axle. The reason for this is that the axle s does not even partially float as it is held in the hub of one of differential bevel gears by threaded retention members. In o to be a semi-floating axle it would be necessary to utilize a bea type at the wheel end that would take end thrust and keep wheel shaft in place while the part of the axle that projected the differential would not be held by any threaded nut.

A true semi-floating axle should be of such form that the may be readily withdrawn without necessitating the complete assembly of the rear construction. The axle shown is semi-floa to a degree, however, because the differential gear is carrie bearings which are outside of the differential case bosses instea bearing directly on the axle shaft, as is the case with light of such cars as the Ford. The three-quarter floating axle sl at B is a design in which the axle shaft is subjected only to sional strains or to a twisting action due to the power appli drive the car. The wheel bearing is mounted on the axle hou instead of inside of that member as shown at A. This bring strain due to the weight of the car on the non-rotating axle l

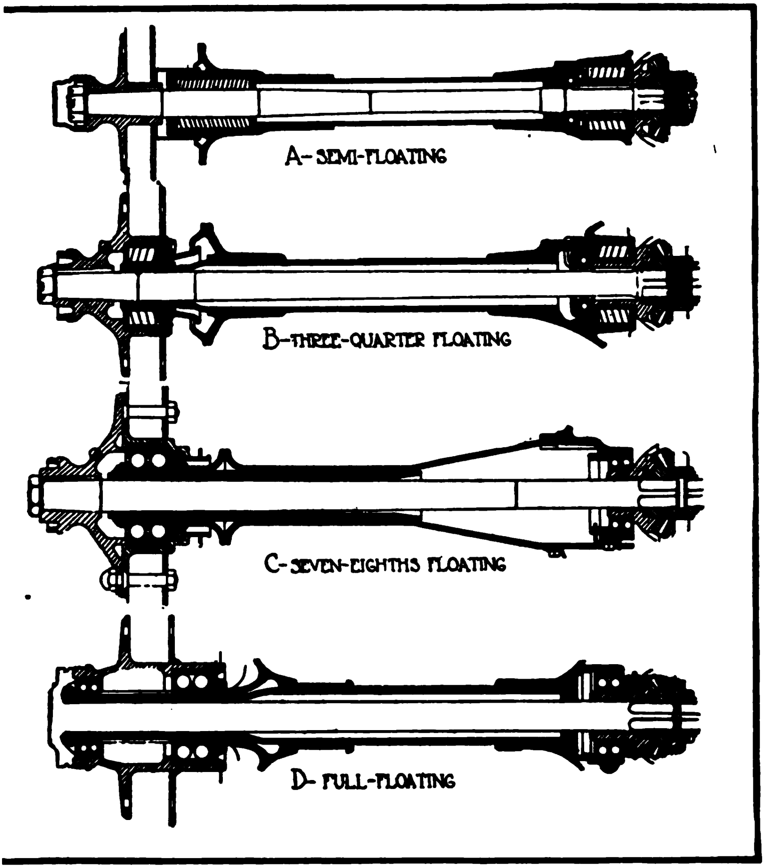


Fig. 372.—Defining Principal Types of Weston-Mott Rear Axle Construction.

g instead of on the shaft as in the type shown at A. The type own at C, which is termed the seven-eighths floating by some gineers and which is called a single bearing full floating hub others, has many of the advantages of the three-quarter floating nstruction in that the drive axle tends to steady the wheel and o has the advantage of the full-floating type in that the wheel y be removed from the rear construction without taking th

housing apart. The axle shaft may be withdrawn from the diffe-ential, which is not possible in the form shown at A and B where the end of the axle is securely retained inside of one of the differ-ential bevel gears by a nut.

The standard full floating type of axle, which is shown at D, does not depend on the driving shaft to steady the wheel, which is held against side movement by spacing the wheel hub bearings on each side of the spoke center line. The advantage of the full-floating type of axle is that the driving shaft may be withdrawn without disturbing the wheels or jacking up the axle and the dif-ferential gearing may be removed from the rear construction by partially withdrawing the drive shafts and not requiring jacking up the axle inasmuch as the wheels still support the load.

Semi-Floating Axles.—The difference between the semi-float-ing and three-quarter floating axles may be readily understood by referring to the sectional views at Fig. 373. The complete as-sembly of the differential and driving gears with one of the axle shafts of a Weston-Mott three-quarter floating rear axle is shown at A, while a similar sectional view of the Reo axle is shown at B. The semi-floating axle used on some types of Pierce-Arrow cars is shown at Fig. 374. It will be observed that in the Reo con-struction the axle shaft must transmit the power and also suppor the portion of the weight of the car that comes on the rear whee it carries. Beginning with the universal joint on the drive shaft the power is transmitted through the pinion shaft to the beve pinion which in turn imparts its motion to the ring gear or maste gear riveted to the differential case. When the car is travelin straight ahead the power is transmitted directly to the two dif ferential gears which are fastened to the axle shaft by keys an taper retaining pins and which turn the wheels forced onto th keys on the tapered outer axle end. When the car turns a corne the outer wheel travels faster than the other, suitable compensa tion for the difference in speed being made by the differential gea and pinions. As will be apparent the pinion shaft is carried b taper roller bearings as is the differential assembly. The axle supported at the wheel end by a Hyatt, high duty type rolle *bearing.*

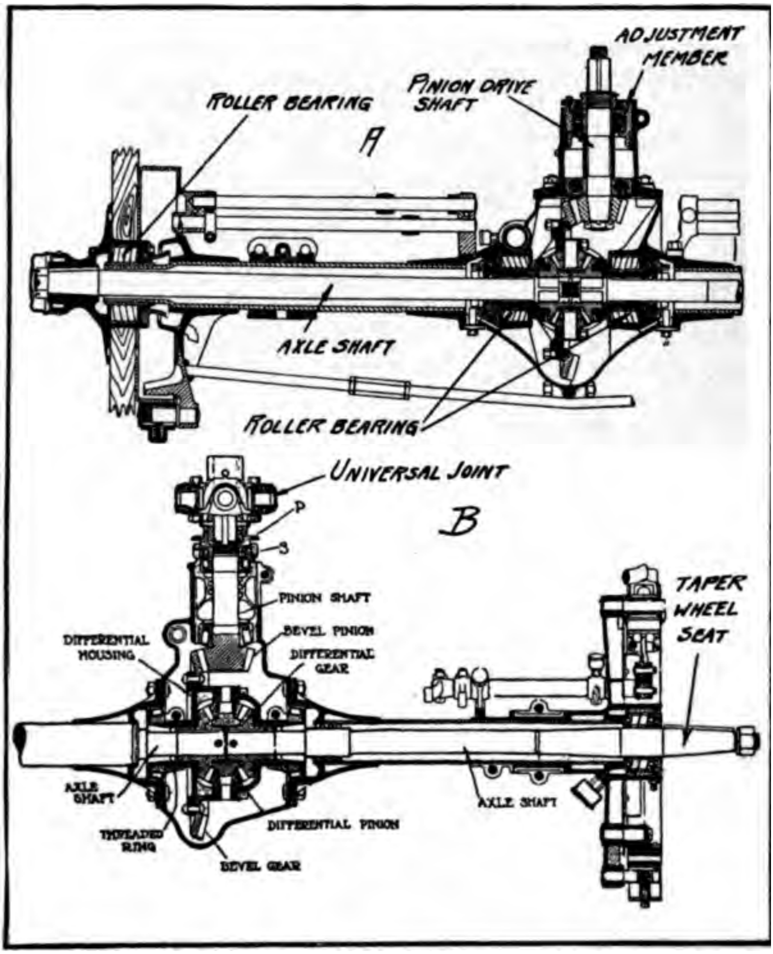


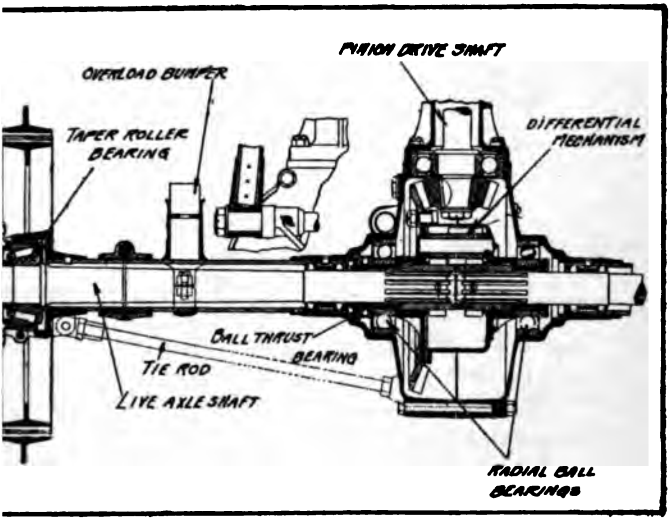
Fig. 373.—Three-Quarter Floating Axle at A, Reo Semi-Floating Axle at B.

There are two adjustments on this axle, one that allows th movement of the differential gearing so the ring gear may b brought into closer mesh with the bevel pinion, when depreciatio *occurs, or in the initial* adjustment when the axle is assembl

The other is the adjustment of the bevel pinion so this als be brought into closer relation with the bevel gear. The f is adjusted by removing the rear of the axle housing and tı the threaded rings that bear against the inner races of the t roller bearings at each side of the differential gear. It v apparent that as one bearing adjustment is turned to pu bearing inner race away from the differential that the othe be turned in toward the differential to permit the other b inner race to move along its supporting boss. The bevel pi adjusted by turning on the sleeve S which moves the pinior and its bearing as a unit. The bearing adjustment is obtai slowly rotating the adjusting member P as desired. By sl the big gear endwise, which means that the entire differentia be moved from one side to the other and the driving pin and out, it is not difficult to obtain correct alignment of the gearing. It is well to have a slight amount of back lash b the teeth of the gears, the amount allowed being about .004 inch. The position of the driving pinion and gear relative t other is very important. Noisy gears are the result of the and gear not being in correct mesh. It has been found that gears are out of position more than 1-100th inch (.01″) th gears will be noisy in action. The exact adjustment can b determined by trial, it being considered more desirable tc some back lash in the gears rather than have them fit too ti

In taking a semi-floating axle apart when of the type sh Fig. 373, B, the first step is to remove it from the chassis, sı it by suitable trestles, and then to pull off the wheels fro taper wheel seats. This is done by unscrewing the wheel ret nut on the threaded axle end and then knocking the wh the axle shaft or pulling it off with a properly designed puller, as shown in Chapter II. or in Figs. 353 and 363 her The next step is to release the axle housing tube from the s the differential housing by unscrewing the nuts that hold the on the axle tubes from the studs attached to the differentia ing. The axle housing may then be easily withdrawn over t after the wheel driving keys have been removed from the wheel seats. This leaves the differential mechanism in place

l housing with the two axle shafts projecting one on each
next step is to unscrew the pinion shaft carrier in order
ıe drive gearing out of mesh. This is done by loosening
ing nut and unscrewing the sleeve S. After the pinion
acked off the differential casing may be taken apart and
er the axle shafts which will give access to the pins pass-
gh the bevel differential gear. These are knocked out



4.—Sectional View, Showing Construction of Pierce-Arrow Semi-Floating Axle.

oles the operator to draw the axle shaft out of the differ-
mbly. After the two shafts have been withdrawn the
l parts may be easily removed through an opening left
off the differential housing cover plate. To take the semi-
le shown at Fig. 374 apart it is necessary to remove the
l part the differential housing on the center line divid-
ıember into two symmetrical halves. Before this can be
inion drive shaft carrier must be removed and the bolts
e halves of the differential housing together must be un-

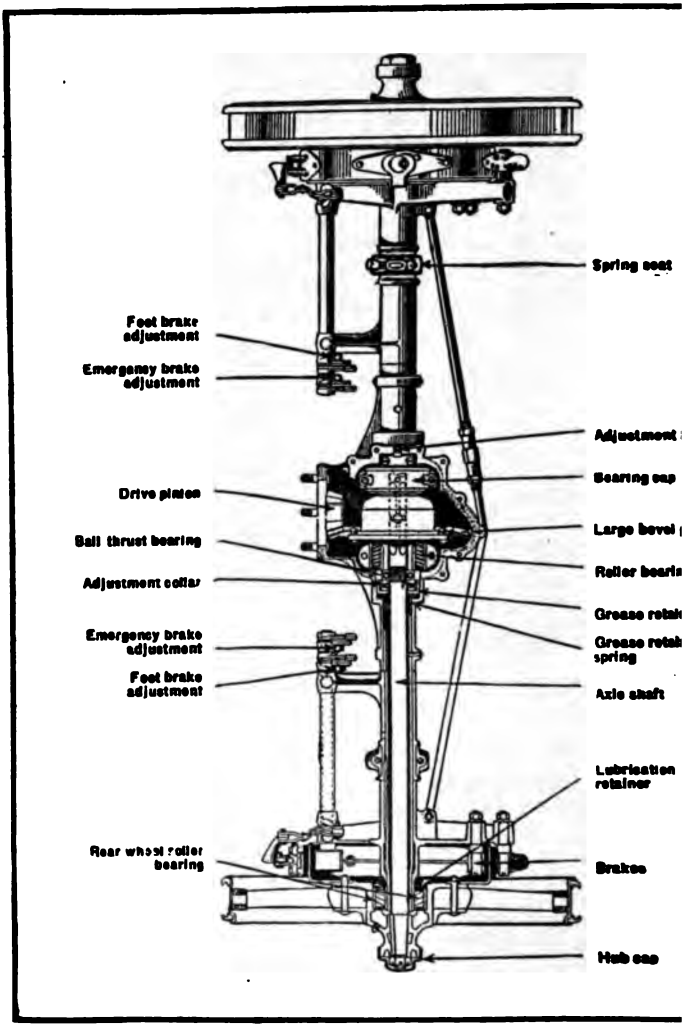


Fig. 375.—Part Sectional View, Showing Construction of Ov Three-Quarter Floating Axle.

:rewed. In this construction, half of the differential housing and ie live axle shaft housing come off as a unit.

Three-Quarter Floating Axles.—The three-quarter floating tle, such as shown at Fig. 373, A, and Fig. 375, cannot be taken part until the wheels have been removed from the axle shaft. ere again it is necessary to take the pinion drive shaft off before e differential housing can be split vertically in the axle shown A. In that shown at Fig. 375, it is not necessary to take the ar construction apart as the differential may be removed from the using by taking off an exceptionally large cover plate. It is cessary to take the wheels off however, in order to permit the thdrawal of the axle shafts. The gears are meshed in the form own at 373, A, by a simple adjustment member which moves the nion drive shaft back and forth in its supporting housing until e proper degree of engagement with the ring gear is obtained. ore detailed instructions for adjusting various forms of bevel iving gears will be given in proper sequence.

Full Floating Axle.—The construction of a full floating axle ed on some Overland models is shown at Fig. 376. In order to thdraw an axle shaft it is only necessary to unscrew the hub cap d pull the driving end of the shaft out of the slots in the wheel b into which it fits. The driving end of the axle shaft is provided th a driving clutch member that is intended to fit into depres- ns milled into the wheel hub. Sometimes the driving clutch will t loose in the wheel hub owing to depreciation of the clutch eth or the slots in which they engage. If the wear is not too eat compensation for the looseness may be made by heating up e ends of the clutch teeth and hammering them out so that they ll be even wider than the slots, then filing them to fit. After e axle shafts are withdrawn if one desires to remove the wheel is may be easily accomplished by unscrewing the locking nut at keeps the bearings in place on the axle tube. The wheel may en be withdrawn with its supporting bearings. To remove a dif- rential gear assembly, one must first withdraw the axle shaft mpletely out of the interior of the differential gearing which is sily accomplished because of the squared ends which fit broached les in the differential bevel gears and then releasing the differ-

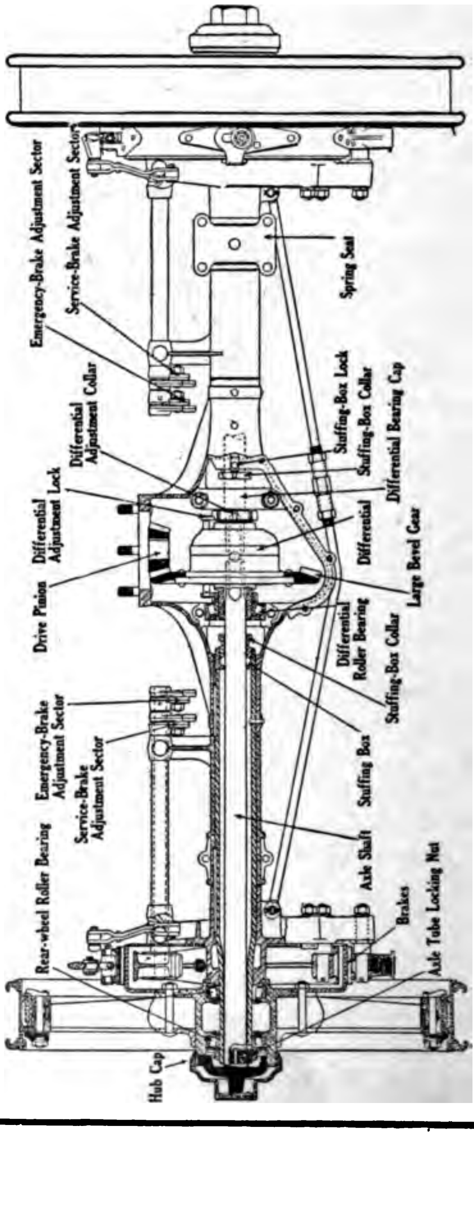


Fig. 376.—Part Sectional View Showing Overland Full Floating Rear Axle.

ıring holding caps by unscrewing the retaining nuts or s. The differential may then be removed from the differ-ng as a unit with its supporting bearings. In this con-it is not necessary to readjust the bevel gearing because tment need not be disturbed when the differential assem-noved. This is a marked advantage of the full floating ;n over the semi- and three-quarter floating forms shown 73.

g Rear Axle Apart.—The parts comprising a typical live ıe non-floating form are shown at Fig. 377. As will be the main portions of the rear construction are three hous-e of these is termed the left half driving gear housing, the right half. Attached to these members are the axle ch carry the brake assembly at the outer end and a spring ·een the driving gear housing and the brake carrying ıch of the axle housings is really comprised of three mem-of these being malleable iron or semi-steel castings joined by a length of seamless steel tubing to which they are attached by riveting and brazing. The propeller shaft ·ries the driving pinion is mounted in a separate housing which has a flange at its lower end by which it may be the differential housing when the two halves comprising ber are bolted together. The axle drive shafts are shown to the differential gears. The parts comprising the dif-assembly are shown at the lower right hand corner of the ın, the brake bands and spring seat are shown at the left ıer.

ler to understand the method of taking the rear construc-t, the method followed in dismantling the Locomobile axle at Fig. 378. While this member has the advantages of oating type in permitting the removal of the wheel drive wheels when necessary, the differential gearing cannot be without taking the differential housing apart. The ap-of the rear construction after the wheel bearings, spring l brake carrying castings have been removed from the housing is shown at A. The first step is to remove the n the studs on the sides of the pinion carrier and the bolts

Fig. 377.—Parts Comprising Early Buick Non Floating Axle.

[redacted]

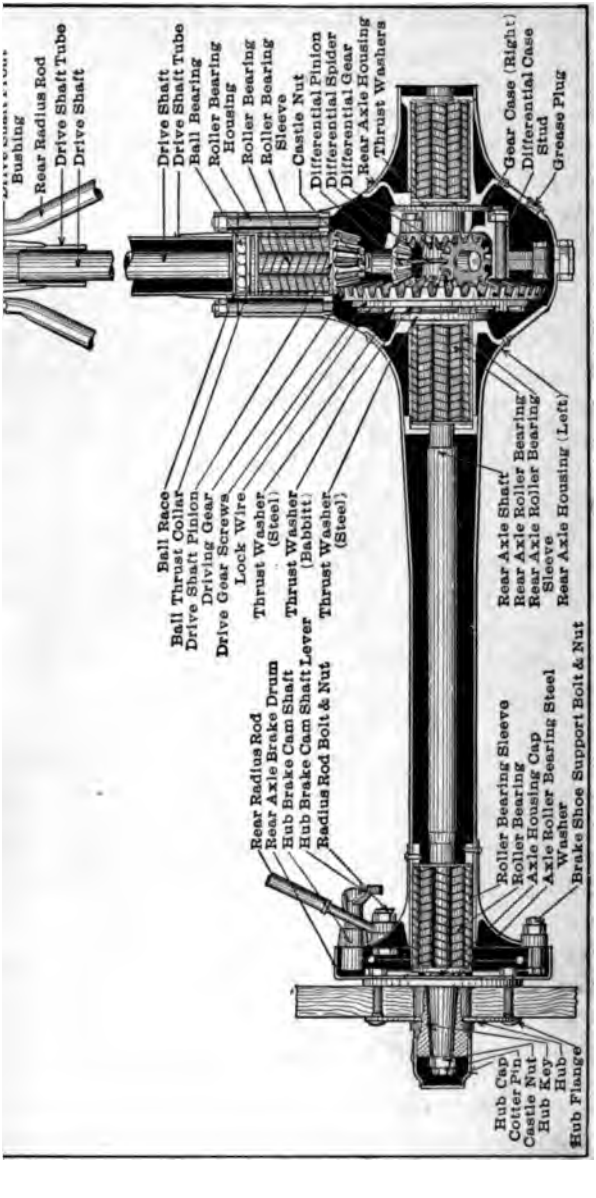
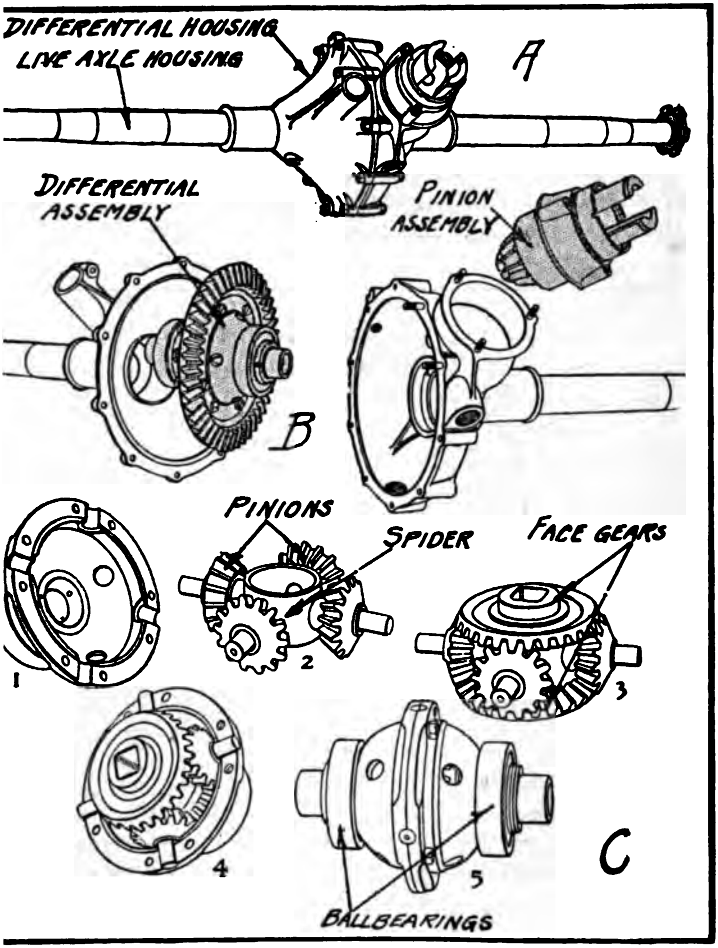


Fig. 377A.—Sectional View of Ford Model T Rear Axle, Showing Driving Gears, Differential, Power Transmission Shafts and Supporting Bearings.

passing through the remainder of the bosses. This permits one to pull the halves of the differential housing apart, exposing the differential gearing as shown at Fig. 378, B. The bevel drive pinion assembly or third member is held in place by three studs in a suitable extension from the differential housing and may be removed from that member as a unit by removing three nuts and withdrawing it from the case.

The parts comprising the differential gear, which is of the bevel gear and pinion type are clearly shown at Fig. 378, C. The differential casing with the ring gear removed is shown at 5. As will be apparent the casing is composed of two halves 1 and 4, these being held together by through bolts passing through the flanges of the case casting. Each flange has four notches of semi-cylindrical form machined therein, these to retain the extension from the differential spider on which the pinions revolve as shown at 2. The spider and pinion assembly in place in one-half of the differential casing is shown at 4. The spider with the bevel pinion and the face gears employed to drive the live axle shafts in the relation they occupy inside of the differential is clearly shown at 3. The points most subject to wear are the bushings in the differential pinions which are usually of bronze and which may be driven out and replaced by new ones and the bushings in the differential case hubs that are employed to support the bevel differential or face gears. If the supporting pins on which the pinions revolve which are part of the differential spider are worn, a new spider member must be substituted for the defective one. But little wear will be found in the teeth of the bevel pinion differential as these are usually a substantial form and because the gearing is thoroughly lubricated at all times. Obviously the process of reassembling the axle is the reverse to that of dismantling it.

Adjusting Bevel Drive Gear.—Bevel drive gearing is supported on two types of bearings, both belonging to the anti-friction class. The type of bearing used for supporting the bevel drive pinion shaft and the differential assembly determines the method of adjustment provided to a large extent. The bevel drive gear assembly shown at Fig. 379, A, is that used on the Hudson Model 37, and is similar in design to that employed on many other cars



378.—Defining Construction of Bevel Pinion Differential Gearing.

is construction taper roller bearings are used throughout. ving common practice in full floating axles the differential nd the pinion drive shaft are supported by a common casting er to obtain correct alignment more easily. The pinion drive is supported by two taper roller bearings, one being placed

immediately back of the drive pinion while the other is used at the upper end of the pinion shaft as a steadying member. The lower bearing is mounted in a threaded adjustment member but the upper bearing seats against a shoulder in the pinion drive shaft housing. In order to mesh the pinion deeper with the ring gear it is necessary to release the adjustment lock that keeps the threaded adjustment from turning and also to back off the adjusting nut for the upper bearing. After the threaded adjustment member has

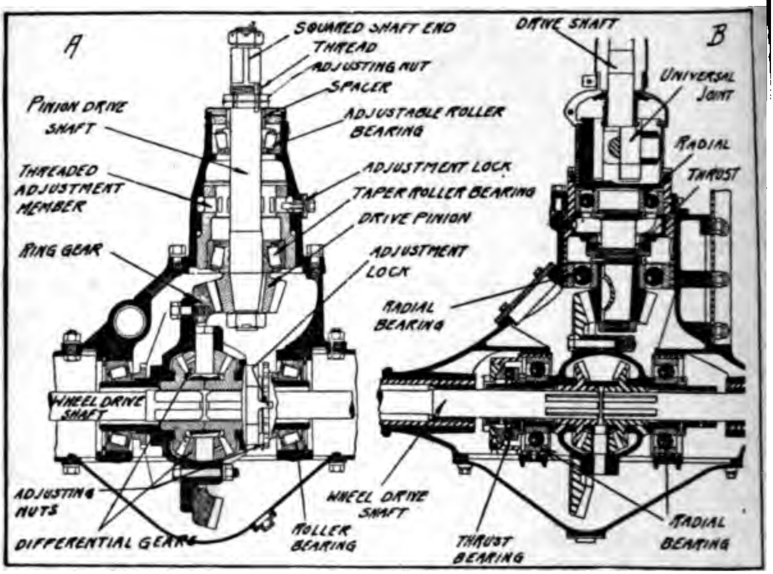


Fig. 379.—Sectional Diagrams of Bevel Drive Gears, Showing Method of Adjusting the Gearing.

been screwed in or out to secure the proper meshing of the ring gear and after it is securely locked in place by screwing the adjustment lock back into one of the slots made to receive it, the upper roller bearings should be carefully adjusted by screwing the adjusting nut against the spacer member, this pulling the inner race of the lower roller bearing firmly against the outer member and in turn seating the outer race firmly in the threaded adjust-

ent member. The adjustment is considered complete when there absolutely no up and down motion to the pinion drive shaft and hen no appreciable effort is needed to revolve it and the differenl gear when the wheel drive shafts are pulled clear of the difrential gear interior.

The adjustment of the differential gearing and the ring gear is complished by threaded adjustment rings or nuts which bear ainst the inner race of the taper roller bearings employed in pporting the differential. These adjusting nuts are provided th a series of slots by which they may be turned and which also rve to receive the tongue of the adjustment lock member. To ove the differential gearing it is necessary to first release the adstment locks and then to turn one threaded adjustment nut in d the other out until the proper degree of engagement of the ars is secured. For example, in the gearing shown at A, if it desired to mesh the ring gear more deeply with the drive pinion e adjustment on the right would be slacked off or screwed in ward the differential a certain number of turns, or such portion a revolution as would be necessary to bring the gears closer tother while the adjusting nut on the left is screwed away from e differential the same number of turns in order to keep the roller arings on both sides in proper relation. There should be abutely no back lash in the taper roller bearings nor lateral movent of the differential gear assembly. At the same time the gearg should be turned without appreciable effort when the pinion ive shaft is rotated by hand.

The sectional view of the bevel drive gearing of the 1914 Locobile is shown at Fig. 379, B. This is similar in construction to at previously described except that ball bearings are used inad of the taper roller form. The pinion shaft assembly is card by two single row radial bearings and one ball thrust washer, e whole being mounted in a carrier member which may be screwed or out of the housing to secure proper gear engagement. The ferential gearing is not adjustable sideways as it is believed that e necessary adjustments can be made by moving the pinion shaft rier in and out of the differential housing. It will be observed at the ring gear side of the differential is supported by a radial

bearing and a ball thrust bearing. This is because the action the inclined bevel gear teeth produces a certain end thrust whi tends to move the differential assembly to the left, this end thr being resisted by the ball bearing especially fitted for that purpo A radial bearing is used on the right hand side of the different casing, this carrying a radial load only. Whenever an adjustm has been altered it is important to make sure and lock it firmly i its new position by the means provided for that purpose. In m cases these are readily apparent upon inspection.

The adjustment of the large bevel gear in the Overland r axle shown at Fig. 375, requires careful attention to details to complish successfully. Take the cover from the differential ho ing by removing the cap screws by which it is retained. Rem the thrust bearing adjustment lock on the side toward which t differential is to be moved with a screw driver and turn the justing cup of the thrust bearing in the same direction. Th various parts are plainly identified by suitable lettering on t illustration. Next loosen the two screws which hold the split d ferential adjusting collar until that member may be turned in t desired direction. Moving the collar on one side of the different makes it necessary to adjust the one on the opposite side acco ingly, both axle ends having right hand threads. When the prop meshing of the gears is obtained, tighten both collars and foll this by bringing the thrust bearings close to the adjusting colla Be sure to tighten all screws and to replace the small locks whi keep the cups from turning after adjustment has been made.

To remove the axle shafts it is necessary to loosen the screws the differential adjusting collar until the threaded portions of t shaft may be withdrawn through the collar. To remove the diff ential gear it is necessary to withdraw the axle shafts first, th to remove the roller bearing retention caps. The differential m then be lifted out of its housing. When reassembling, it is impe tive to mesh the bevel gears correctly and to adjust the ball thr bearings properly, taking care not to get these too tight agai the differential adjustment collars. If the axle leaks oil it is ne sary to renew the grease retaining felt washer.

All differentials and driving gear assemblies are not capabl

adjusted as in some axles one depends more on a close fitting parts when the axle is first constructed. Two types of differ-s that cannot be adjusted to change the relation of the driv-earing are shown at Fig. 380, B and C. That shown at B een used on a number of Pierce-Arrow models and as will be

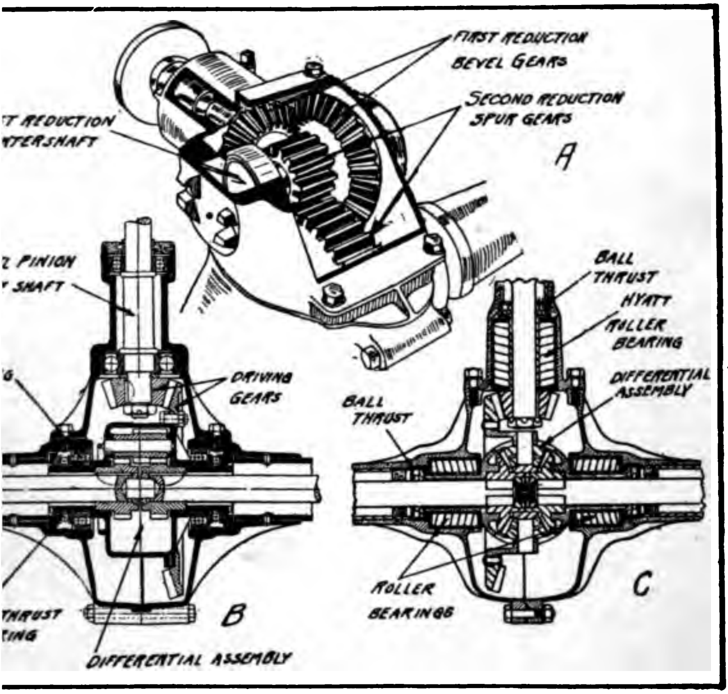


Fig. 380.—Showing Construction of Non-Adjustable Bevel Gear Drive Units.

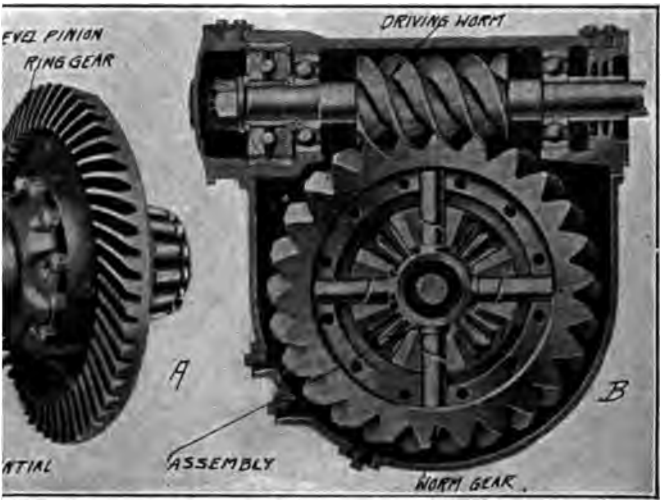
ent the differential housing is divided vertically in the cen-d no provision is made for adjusting the ball thrust bearing ted at either side of the differential case. As but little de-ition will exist in a well designed and properly constructed xle it is believed that any depreciation can best be remedied e substitution of new parts for those that have become worn.

The same is true of the assembly shown at C. In this roller bearings are used to support the differential while ball thrust bearings are depended on to take the end thrust on the wheels as well as that produced by the bevel gears. When these axles are taken apart there is only one way in which they can be reassembled as far as replacing the bearings is concerned, although on many types in which symmetrical axle housings are used it is possible to replace the differential assembly so the master gear will be on the wrong side of the pinion. This will result in the rear wheels turning backward when the forward speed ratios are engaged and of turning forward when the reverse gears are in mesh in the transmission. The bevel gear in the assembly shown at C, is on the right side of the pinion for engines as ordinarily constructed, that is, those turning clockwise. In the assembly shown at B, the differential is placed in such a way that if used with an engine turning clockwise the drive will be reversed when the forward ratios of the gearset are engaged. Care should always be taken when an axle is dismantled to notice the relation of the parts before they are taken out to make sure that they are replaced correctly.

In some cases double reduction gearing is used in the rear axle. This is employed in gasoline commercial vehicles and some electric pleasure cars. The rear construction shown at Fig. 380, is that used on the Autocar trucks and combines spur and bevel gears in such a manner that two reductions of speed are obtained in the axle housing itself. On the end of the drive shaft a bevel pinion is carried which meshes with the ring gear which instead of being attached directly to the differential as in the conventional construction, is employed to turn a countershaft on which a spur pinion is mounted. A spur gear is secured to the differential and meshes with the spur pinion on the cross shaft. A primary reduction is obtained between the bevel pinion and gear, the second reduction of speed being secured between the small spur pinion on the cross shaft and the large spur gear attached to the differential. A differential cross is carried in the interior of the differential case and the bevel pinions of the differential revolve upon the arms of the cross. The gears in the interior of the differential are carried in the differential case by means of bronze bushing and the hole through

is broached to fit the inner ends of the wheel driving s not difficult to remove the differential assembly from ; the top portion carrying the bevel drive gears in the tion countershaft may be lifted off of the differential ter the driving shaft is disconnected, and then the dif- ear assembly can be lifted out of the housing member ie manner as described for the full floating single re- les.

ınd Spiral Bevel Drive.—In an endeavor to secure quiet while running, which is not always possible with the



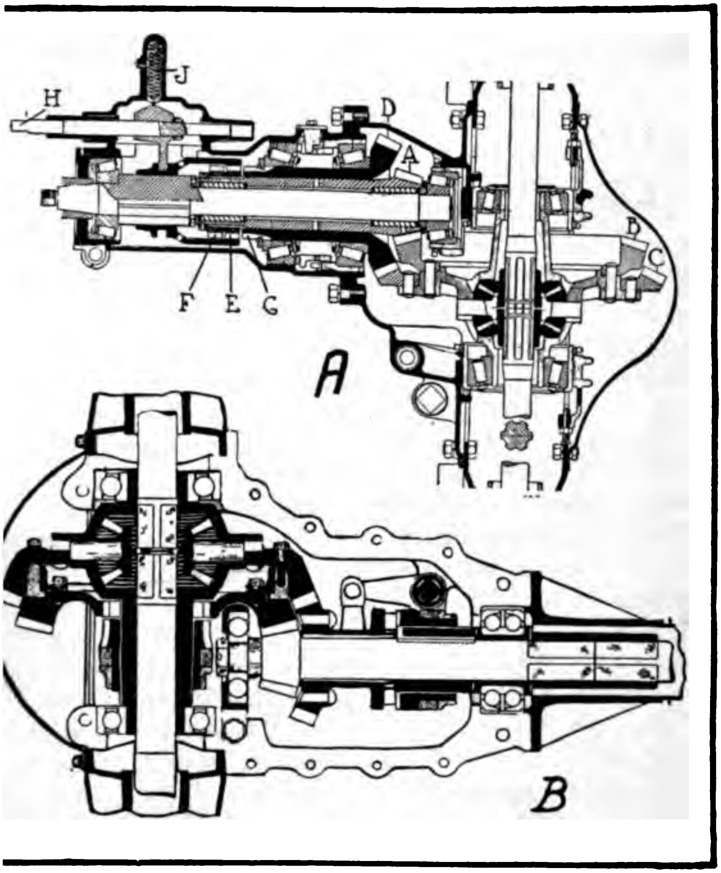
-Outlining Construction of Spiral Bevel Drive Gearing at A and Worm Drive Gearing at B.

pe of bevel gears, a number of automobile designers have e spiral bevel drive gear which is shown at Fig. 381, A, e car service and the worm gearing shown at B for com- hicles. The advantages of the spiral bevel gear are : to the shape of the teeth which roll into engagement :hly than the ordinary form of bevel gears. It is stated piral bevel driving gears the gears need not be meshed ly as with the straight gears to secure quiet operation.

The same rules that have been previously given for adju straight bevel gears apply just as well to the spiral bevel forr

The worm drive axle as usually constructed is so devised the initial adjustment provided at the factory by careful mach of parts is never disturbed except through wear. If an adjust is provided on either side of the differential assembly to whic worm gear is fastened, great care must be taken to line up the ing in such a way that the center line of the driving worm coincide accurately with that of the worm gear. In taking do worm drive axle it is necessary to examine the condition of th thrust bearing carefully and to make sure that all parts of member are clean and in good condition. Very large thrust are imposed on the supporting bearings of both worm and gears so it is important to always adjust these members so that can take this thrust load and make sure that the single row r bearings are not subjected to any end thrust. In the best de of worm drive axles, the worm gearing is carried by a suppo casting which permits of careful alignment before assembling the axle housing. The worm gear is usually made of hard b while the driving worm is of hardened steel. If lubricatio been neglected or if oil of insufficient body has been used, mo the wear will be found on the teeth of the worm gears. The no compensation possible for reduction in tooth size other tha placing the worn gear with a new one.

Two Speed Axles.—The repairman is apt to encounter axles in which two sets of bevel driving gears are used in ord provide two speeds in the axle itself. That shown at Fig. 38 was used on 1914 Cadillac cars while that shown at B is the A design and has been used for several years on cars of that The construction of the Cadillac two speed rear axle, whicl made by the Timken Axle Company, is shown at A. The po transmitted from the drive shaft of the gear set in the usual ner through either of the bevel gear sets A and B or C and D. the inner set the ratio is 3.66 to 1 on the high gear while wi outer sets the ratio is 2.5 to 1. The two large bevel gears C are riveted to the differential gear housing, though one pinions A and D that drive them is always loose on the drive



ig. 382.—Examples of Two Speed Rear Axle. A—Cadillac 1914. B—The Austin Construction.

ı A is carried by roller bearings while pinion B revolves on n roller bearings carried by the casing. A sliding dog clutch ›r E may be employed to clutch either clutch teeth F which bevel pinion A or clutch teeth G which drive bevel pinion he sliding clutch is operated by the shifting rod H which is tically operated and which is locked in either position by ring J.

The construction of the Austin axle is somewhat different this design two sets of clutches are used, one working on th ferential, while the other works on the drive shaft. To driv car with the larger bevel gears the clutch member on the shaft is engaged with the dog clutch attached to the sleeve to the larger bevel driving pinion is attached. Movement o clutch simultaneously operates that on the differential case sion so the smaller of the bevel ring gears is disengaged. The is then through the large bevel pinion and the large ring gea obtain the other gear ratio the clutch on the driving shaft is s out of engagement while that on the differential case is shifte place inside of the smaller of the two bevel driving gears. this is done the small driving gear is coupled to the differenti ings by means of the clutch and is driven from the small pinion on the drive shaft. The large bevel gear which is att to the differential revolves the bevel pinion with which it n idly on the driving shaft. The clutches are interconnected lever so that one cannot be engaged without releasing the

Obviously there are more parts to wear in the two spee and failure to drive on either gear ratio must be due to clutch action. In view of what has been said previously about gear adjustment there should be no trouble experienced in ing proper driving engagement of the bevel gearing when a ments are provided for this purpose. In the Cadillac desig entire differential assembly may be moved over just as in a speed axle. In the Austin design shown at B, no provision is for gear adjustment other than that initially provided whe gearing was assembled at the factory. In the Austin axle bearings are used inside of the sleeve carrying the largest drive pinion and also to support the smaller of the bevel gears. Any depreciation of the plain bearing surfaces will in noisy action and can only be prevented by replacing the bushings with new.

Double Reduction Axles.—In commercial vehicles it is able to use a lower driving ratio than could be convenientl vided by a single pair of bevel gears, and yet it is desirable tain the advantages of the full floating type of axle. A t

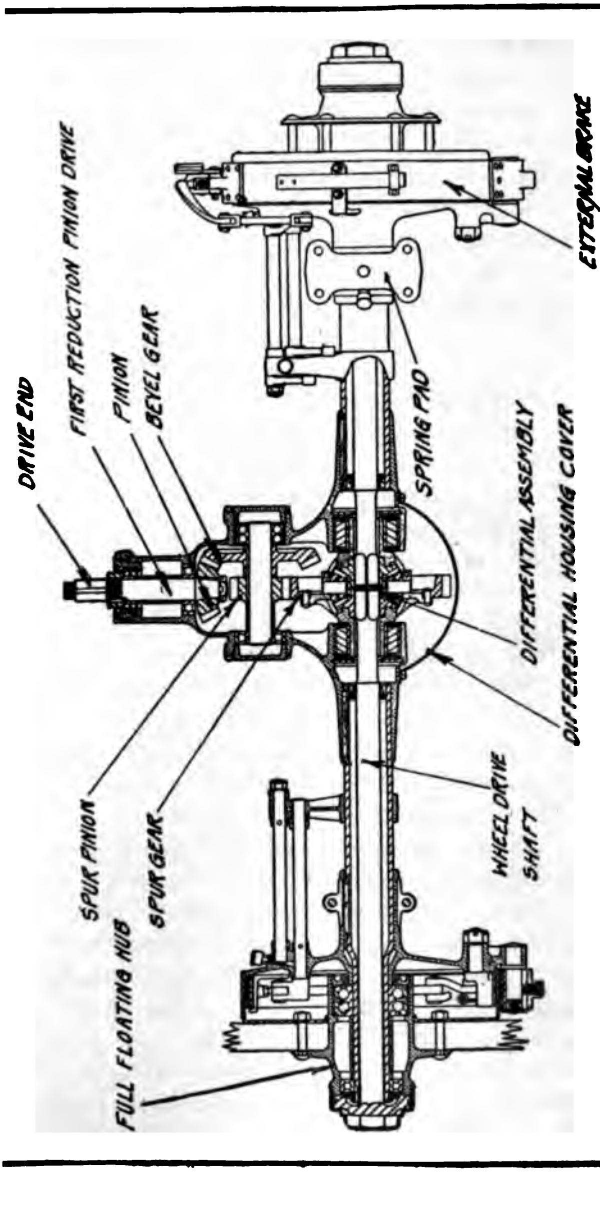


Fig. 383.—Sectional View of Weston-Mott Double Reduction Full Floating Rear Axle.

double reduction axle of Weston-Mott design is shown at Fig. 383. In general construction and arrangement of gears the axle is very similar to that used on the Autocar and previously described. This is a built up construction consisting of cast malleable iron differential housings and heavy steel tubes swaged down at their outer ends to take the bearings on which the wheels are mounted. The differential is mounted on high duty roller bearings having only plain thrust washers to hold it in place because there is no side thrust from the spur driving gear. The differential assembly is driven by a large spur gear meshing with a pinion on a short countershaft in front of the differential. This shaft is driven by bevel gears from the propeller shaft in the usual way. The housing is split vertically through the center line of the short shaft and has a pressed steel inspection cover at the rear. The parts may be examined by removing this cover. As is true of all full floating axles the axle shafts may be withdrawn by merely removing the hub caps serving to keep them in place.

Another form of double reduction axle is shown at Fig. 384. This is known as the internal gear drive type and is very satisfactory in commercial applications. The main feature of these axles is the combination of a non-revolving load carrying member with a jack shaft similar in construction to a live rear axle which drives the rear wheels through the medium of small spur pinions meshing with large internal ring gears. As shown in the drawing the carrying member is an I section drop forging upon which the wheels are mounted. There is an opening in the center of the forging in which the central housing member carrying the differential assembly and driving pinion is securely bolted. The power transmission member is located at the rear of the supporting axle. The construction is such that the differential assembly may be removed without taking the entire axle apart, though the wheels must be taken off of the spindle to permit the withdrawal of the pinion drive shafts. The method of adjusting the bevel pinion is the same as has been previously described in which the entire pinion assembly including the drive shaft and supporting bearings may be moved in or out to mesh with the differential ring gears. To adjust the gears to one side o the other the lock members carried at the rear end of the axle w

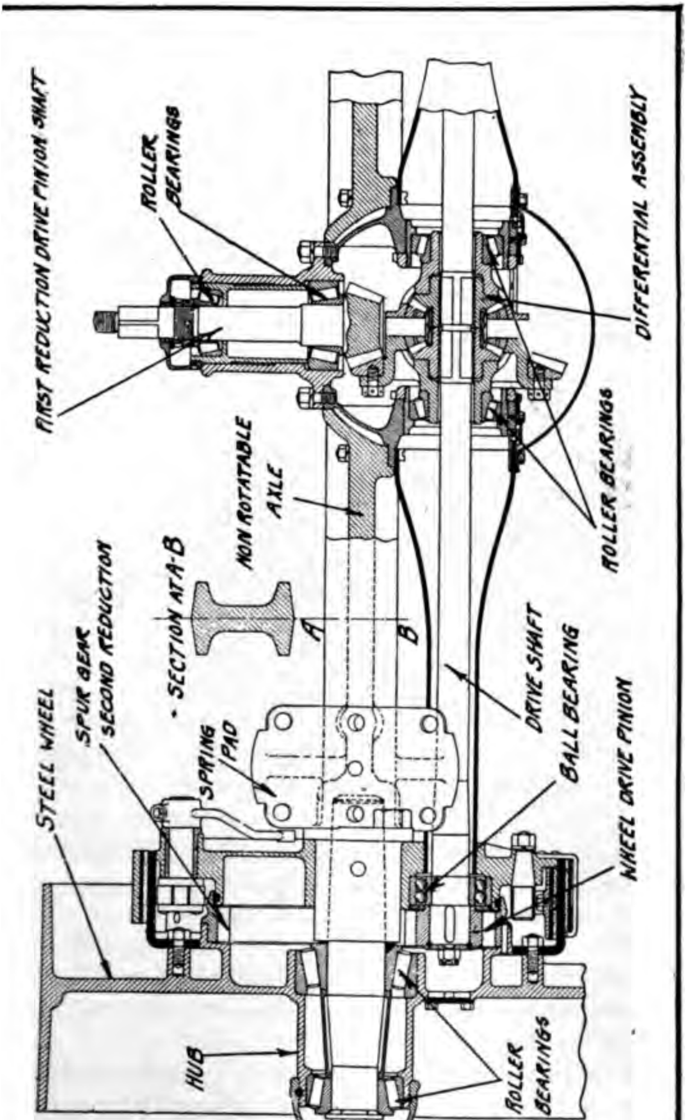


Fig. 384.—Part Sectional View Showing Construction of Internal Gear Drive Rear Axle.

which are removed by taking off the pressed steel cover must be released. The taper roller bearings are carried in cages or ings provided with threaded adjusting nuts which may be us draw the housing of the bearing the way it is desired to adju ring gear. Obviously it will be necessary to loosen one of the

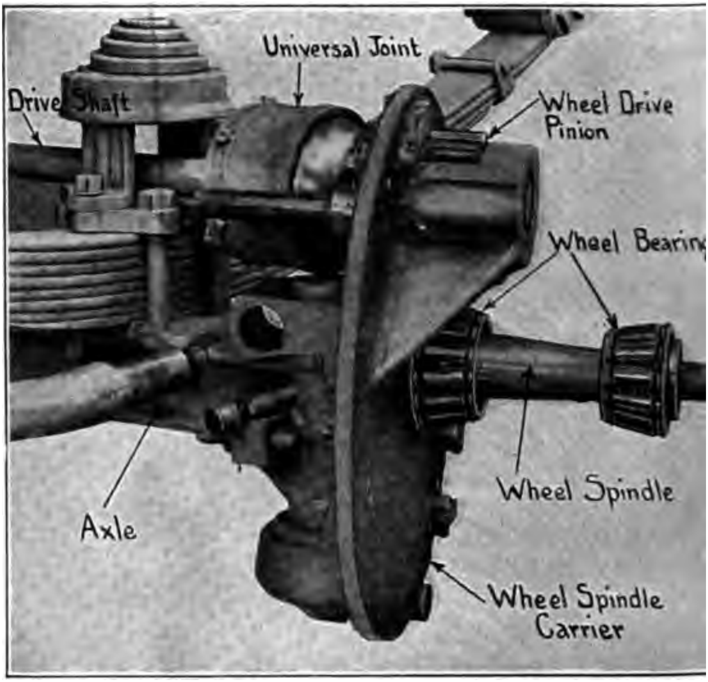


Fig. 385.—Showing Arrangement of Mobile Wheel Spindle Us Jeffery Four Wheel Drive and Steer Truck.

by moving it toward the differential assembly the same num turns that the other adjustment member is screwed away fr assembly when adjusting gears.

Four Wheel Drive Systems.—There is a growing appre of the value of having all four wheels of commercial vehicle bine directive and tractive functions, especially if these are employed for towing trailers as well as carrying a load o

orm. One of the leading exponents of the four wheel ɘm in this country is the Jeffery Company, the chief pe- n its design being in the construction of the axles. Both rear axles are the same in construction, the general de- ; shown at Fig. 385. The wheel carrying spindle is at- a member that may be moved back and forth on the axle eering the same as the front wheel spindle of any car is. ɔd of imparting the motion of the driving shaft to the ı when that member is at an angle for steering is simple. tial assembly is carried by the non-rotatable axle forging, to the wheel being through a drive shaft and universal ·hed to the wheel drive pinion. The construction is simi- t of the internal gear drive previously described, except ıversal joint is interposed in the driving shaft to permit drive pinion to assume the same angle as the wheel spin- r without excessive loss of power.

ınd Bevel Gear Differential.—Differential gearing is of patterns, that shown at Fig. 378, C, being termed "bevel " because only bevel gears and pinions are employed ; outlined at Fig. 386 is known as a "spur gear differen- ıuse gears of the spur form only are used in providing ɜ of wheel speed when turning corners. The differential ·t of the automobile that seldom gives trouble, the bevel ·m being stronger as a rule and less liable to breakage using spur pinions. If the differential is at fault, trouble perienced in steering the car around corners if the parts ·d together so that none of the gears can turn, whereas if ıre broken or sheared off it will be impossible to drive the ɔre the advent of high grade alloy steels and before the t treatment was as well understood as it is at the present ·rential gears of the spur pinion type were apt to become 'e through the gears cracking or the teeth stripping. At ıt time these troubles are not apt to occur because high ɜls are used in differential constructions. When testing he differential is in good condition it is necessary to jack ır axle till the wheels are clear of the ground. One wheel turned by hand and if the other turns in the same di-

rection and cannot be prevented from rotating except by th tion of considerable effort to restrain its movements, it is that the differential gear is not functioning properly and is stiff in action. On a number of early makes of cars; esp cheap ones, the bevel differential gears were held on the whee axles by pins which were apt to shear off after being in u some time. This will permit the gear to revolve independer the shaft and not drive the wheel. Another fault was shear the retaining bolts or rivets that held the differential assembl the ring gear together. This would permit the driving gear volve without turning the differential case.

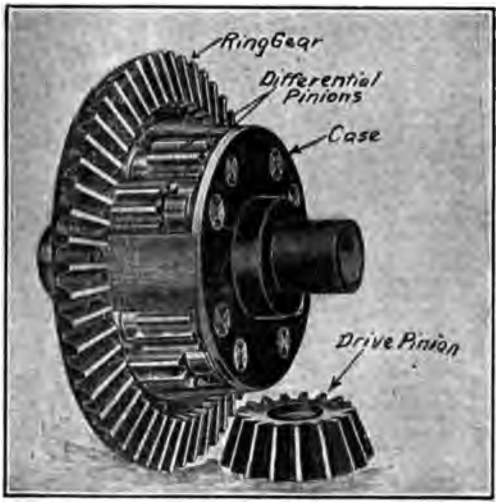


Fig. 386.—Spur Gear Differential.

In most bev ferentials and spur forms the pinions are bu where they revo a supporting After the diffe has been in use period, and esp when lubricatio been neglected, bronze bushings become worn e so the bevel p will be loose on supporting pins case and the spu ions have lost on their supporting axles in the other. As these bushings a adjustable it is necessary to drive out the old ones and to fo new ones to compensate for this depreciation. The gears attac the wheel drive axle are employed in a number of cases to s the drive shafts rotating with them in the differential casings. lost motion in the bushing surrounding the face gear hub m taken care of by forcing in new bushings in the differenti bosses. The method of taking a bevel differential apart is

utlined at Fig. 378, C, as is also the relation of the various parts n different stages of assembly. The housing of the average spur inion differential may be taken apart by unscrewing the pins on which the differential pinions revolve as these also serve as retenion members to keep the two members comprising the differential ase together.

Chain Drive Troubles.—There are very few chain driven pleasre cars in use at the present time, these generally being models ve or six years old. Chain drive is still used extensively on commercial vehicles, however, so it will be necessary to give some intruction for the care and adjustment of chains. Most of the roubles in chain drive are due to worn driving chains or sprockets. The reason for this depreciation is that chain drives, for the most art, are run without any protective casing and grit and dirt colect between the chains and sprockets and in the bearing surfaces f the chain itself, and if not removed by frequent cleaning of the hain it will rapidly grind away the sprocket teeth and cause the hain to become very loose. A typical chain drive system is shown t Fig. 387. The wheels revolve on a non-rotatable axle, being caried in most cases by some form of anti-friction bearings. Power s transmitted from small sprockets carried by a jack shaft suported by the chassis frame to the larger rear sprockets usually ecured to the brake drums by means of some form of steel link hain, the roller chain being the form most generally applied. If he sprocket teeth are worn hook shape, it is necessary to replace he sprocket with new ones. If the chain is too loose, so that it "whips" when in service, the radius rods that are fastened to the xle at one end and the jack shaft at the other may be lengthened y the adjustment means provided to increase the center distances etween the driving and driven sprockets. Tightening chains must e done with judgment as it is more undesirable to run them too ght than it is too loose. When a chain has been tightened to a ufficient degree there should still be a small amount of slack which ill permit the chain to drop at its lower side as shown at Fig. 387.

A driving chain is tested for wear by bending it sideways to eel the looseness between the link pins and bushings. After considerable wear has taken place on each of the bearings of the chain

links the chain will have lengthened out of pitch and should not be run as it will produce rapid wear of the sprockets. After a chain is worn it is apt to break when a load is suddenly applied, or when the engine is called upon to exert its maximum power as in climbing grades. The two forms of chains that have been generally applied for driving an automobile are the roller chain as shown at Fig. 388, B, and the silent chain shown at Fig. 389. The

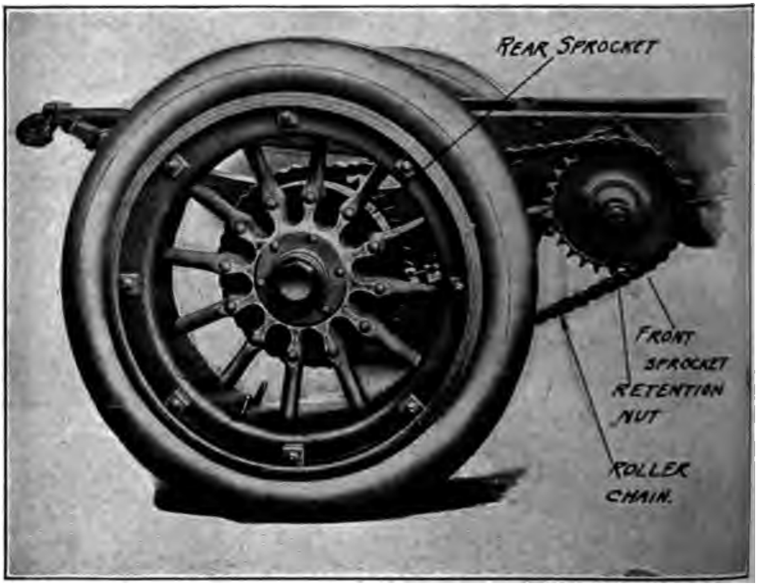


Fig. 387.—Practical Application of Side Chain Drive.

block chain, which is shown at Fig. 388, A, has been seldom applied except on very early forms of automobiles. The roller chain is made in two main types, the quick detachable which is shown at B, and the riveted type as shown at C. With the riveted type new links can be replaced only by driving out the rivets with a steel drift after the ends have been ground off to permit driving the rivet out of the side plate.

Quick detachable types offer the advantage of being taken apart at any point by removing a simple lock member which may be

ıe form of a stamped plate, as shown at B or a split pin passing ırough the end of the rivet as shown at D. Even the riveted types f chains are joined together by a quick detachable link member hich is called "a master link" to permit taking the chain off of

Fig. 388.—Showing Forms of Driving Chains and Repair Links for the Same.

ıe sprocket without having to drive out retaining rivets. The ıain repair links are made in a number of types, those shown at and F, Fig. 388, consisting of two side plates with the rivets pins that form a bearing for the roller link shown at G. When is not possible to shorten a chain by removing a roller link as G, and one of the pin-carrying links as at E and F, a special

off-set link shown at H is provided. As will be apparent this join one of the side plate links with one of the roller carrying li The method of taking the chain apart shown at B may be r ily understood. The ends of the roll carrying pin are provi with annular grooves machined around them. The locking m ber is a stamped steel plate which is pushed over the pin and wl has a horizontal slot in one end that is slightly less in width t the diameter of the rivet pin, and which therefore cannot come of the pin when it is forced into the groove at the end of the]

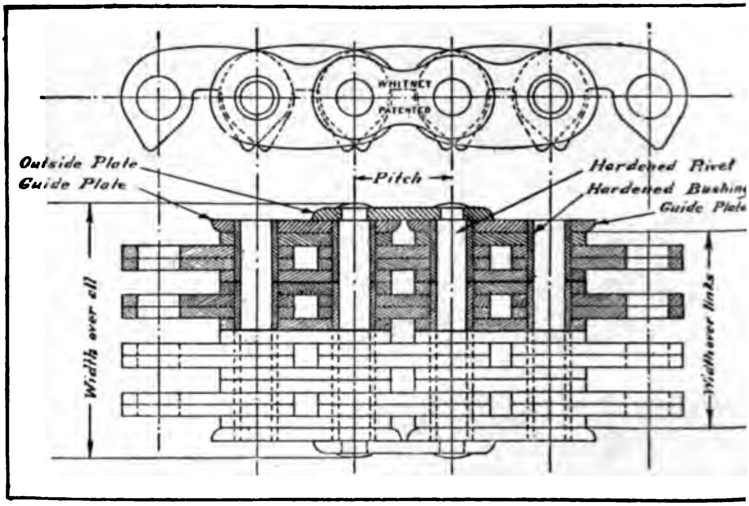


Fig. 389.—Showing Construction of Whitney Silent Chain.

After the horizontal slot has been pushed over the pin, the e carrying the vertical slot is pulled down over the other pin. T chain side links are provided with depressions in which a suital raised punching in the link locking stamping springs when ' locking member has been pushed in place. In the section of ch shown at B, the locking member at the left is about to be pusl in place while that at the right is shown in the position it occup to prevent loosening of the chain link.

The method of locking the master link on the Baldwin chai clearly shown at Fig. 390. In this washers of soft steel are u

to fit the locking grooves in the end of the rivet pins. After t washer has been sprung in place, it is tightened around the p with a pair of pliers. In the Whitney chain, also shown at F 390, the side plates are held by split pins which may be readily r moved when it is desired to pull off the side plate. It is often fou difficult to replace a large heavy motor truck chain on account trouble in bringing the links sufficiently close together to slip the master link. This may be easily overcome by using a simp tool shown at the bottom of Fig. 390. This consists of a pair hooks made of stock sufficiently small in diameter to go betwe the rollers and side plates of the chain link. One of these hooks is provided with a right hand thread, the other with a left hand thread. A piece of hexagon bar stock, four or five inches long, is provided, a hole being drilled clear through. One end is tapped right hand to match the thread on one hook, while the other end is tapped left hand to fit the thread on the other hook. When the hooks are started into the ends of the threaded bar, a very effective turnbuckle arrangement is obtained by which all slack may be taken out of the cha and the links brought near enough together to insert the mast link.

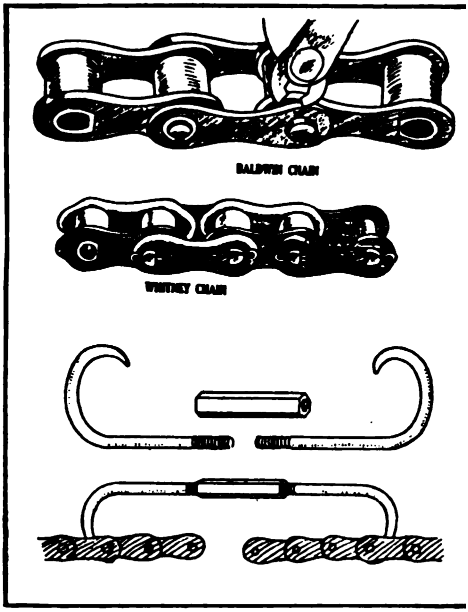


Fig. 390.—Two Types of Quick Detachab Chain Links and a Simple Tool to Faci tate Insertion of Master Link.

If chains are properly cared for they will not wear as qui

as when neglected. The careful truck driver will remove the chains every week and allow them to soak in kerosene so that all grit will be washed out of the joints. After this, the kerosene is thoroughly wiped off and the chain is immersed in melted tallow and graphite until the lubricant has a chance to penetrate between all the rivets and roller bushings. The surplus lubricant is wiped off of the chain after it has been allowed to cool and the chain replaced. The practice of oiling the chains with an oil can or with grease applied to the surfaces is not conducive to long chain life because it only serves to collect the grit and lead it to the bearing surfaces. The silent chain, which has been adopted in a number of cases for camshaft drive in the engine and for coupling up starting motors and generators to the crankshaft, may also be used for final drive. It has been used in friction drive cars, notably the Lambert, Carter car and new models of the Metz touring car. Where this type of chain is used it is usually protected by a casing and runs in an oil bath. When mounted in this manner the silent chain is not apt to depreciate rapidly, as is true of the roller chain when the links, rivets and bushings have worn the chain will stretch out of true pitch and will become seriously weakened. If there is unusual wear or lost motion at these points the only remedy is replacement with a new chain. Whenever a new chain is installed on a car, it is imperative to replace the sprockets as well because a new chain will not run well on worn sprockets, nor will new sprockets operate properly with a worn chain.

Live Axle Repairs.—Among the parts of the live axle that demands inspection from time to time are the differential and driving gear assembly, which have been previously described, and those parts of the rear construction upon which its structural strength depends. There are other points, such as spring seats, the brake mechanism and the bearings upon which the various rotating members are carried that must also receive attention. Noise from a rear axle often results when bearings that are too small have been used or when these have been of a type not properly adapted for the work they were expected to perform. For example, a number of axles has been marketed in which only single row or radial bearings have been used to take the thrust between the bevel drive gears in

ead of supplying bearings especially adapted for that purpose. ne pressure of the bevel gear teeth, as soon as it reaches a cerin point would cause a wedging of the balls and races, especially hen the car is on the lower speed ratios or if the transmission ake is applied sharply at full speed or if the wheel brakes are apied without releasing the clutch. A harsh acting clutch will also npose these intermittent wedging stresses on the bearings. This unfortunate because if by any such action the ball bearings have een put out of line, the distortion between the inner and outer ces will result in rapid bearing depreciation which of course pro-uces considerable noise. Another trouble met with in semi-floatng axles is replacing wheel drive shafts for defective ones that are o short and which do not abut inside of the differential. In this se when one rear wheel skids violently or is thrown against some bstacle on the highway the severe end thrust shock is frequently ansmitted to a bearing supporting the differential which results these members depreciating sooner than they would if subjected nly to the load they are supposed to resist. It is considered good ractice to transmit the shocks from one wheel to the other through e middle of the axle without engaging the differential housing. his is done by the manufacturer when he establishes a contact beween the two inner ends of the wheel shaft. When the shafts are placed or repaired care should be taken that this mutual abutent takes place as intended. In some designs a large size steel ll is placed between the axle ends, in others, fiber or steel washers aving curved and straight sides are used, the curved sides being aced against each other, while the straight sides are placed against e shaft ends. Shafts of three-quarter or full-floated axles are t supposed to abut.

The rear axles of many shaft driven cars are braced with tenn rods, but after being in use for a time the vibration of the le and the up and down hammering action that obtains over ugh roads eventually lengthen the rods and relieve their tension, ich, of course, results in a cessation of the functions they are ended to perform. The tension rods should be carefully examd from time to time to make sure that they are properly tighted as if loose a certain amount of sagging will take place which

results in lack of alignment of the parts carried by the differential housing which will result in noisy action. Many cases of distorted axle housings have been noticed in light cars that have been operated over rough roads. This will result in the wheels being bowed so that the tops are nearer together than the bottom, as shown in Fig. 391. In many cases the sprung axle housing may be drawn back in line and materially strengthened by the use of a truss rod placed under the differential housing and attached at the wheel end of the axle by some form of clamp, passing around that member.

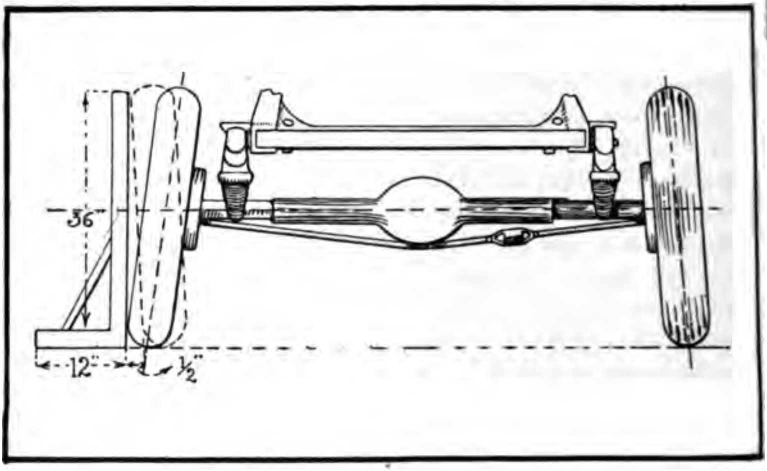


Fig. 391.—Method of Bracing Sprung Rear Construction by Truss Rod.

The rod should be at least half an inch in diameter and be made of cold rolled steel. A turnbuckle is placed in the rod to draw the parts together and straighten out the axle housing. The condition shown in the diagram is exaggerated in order to make the defective condition clearer. It is not possible to take out all the sag if an axle has been neglected and it is also important to notice whether the wheels are loose because of worn bearings or whether the wheel driving axle is bent before any attempt is made to compensate for this defective condition by trussing under the rear construction.

In many cases where the bevel driving gears have worn the repairman has the job of replacing the worn parts. In some ca

he ring gear is riveted to the differential case flange, though in nost of the modern designs it is attached to that member by means f bolts. If the threaded retention members are used it is not a lifficult proposition to remove the bolts and the old gear and fasten he new one in place. Where the ring gear is attached by rivets, owever, an entirely different procedure must be followed. The irst step is the removal of the old gear by chipping off the rivet eads with a sharp chisel in order to drive the old rivets out or to lrill out the rivet head if this is of the countersunk type. After he rivets have all been driven out and the old ring gear removed, he flange should be carefully gone over and all upstanding burrs hould be smoothed down with a file. Any irregularity on the lange will result in the ring gear being out of true, as far as its neshing with the driving pinion is concerned.

Hot riveting is preferable to cold riveting because when the ivets are put in red hot they fill the holes better as they are headed ver and additional holding power is secured by the cooling shrink. n order to make a neat job of riveting it is imperative to use a ivet set. A skillful mechanic may be able to form up a head with peening hammer but this at best is a slow job and there is always ome danger of injuring the differential casing or the gear teeth hould the hammer slip.

A rivet set is very easily made by using a bar of steel about ne inch square and five or six inches long, tapering off the end so t will fit in the space between the gear teeth and the differential asing and forming the depression in the end that makes the rivet ead either by drilling in with the point of a drill, or by heating he bar of steel to a good forging heat and making the depression y driving a rounded bar of steel to conform with the rivet head nto the headed end.

The usual size of rivet used on small cars is ¼-inch. On the arger pleasure cars, 5/16-inch or ⅜-inch diameter rivets will be sed. The rivet should be sufficiently long so that it will project hrough the flat surface against which the head is to bear a length qual to 1½ times the diameter of the rivet stock. The work of iveting must be quickly done. The rivets are heated in a forge nd when red hot are placed in the hole, the head end down against

an anvil while the projecting end is headed over with a riv and a 5 pound hand sledge or machinist's hammer. After th rivet has been placed, the next one to go in should be put i metrically opposite. This holds the gear firmly in place a the differential gear case flange, after which the other rivet be put in as suits the convenience of the operator. It is w bear in mind that a well rounded rivet head is apt to have strength than large, roughly flattened heads that have beei duced by hammer blows and without the use of a rivet set.

Axle Lubrication.—Many cases of noisy driving gears from lack of lubricant in the differential housing, and a num cases of rapid depreciation of live axle bearings have been t to neglect in these essential The reason for t that most of the members are lubr through the medi compression g r cups, which are or less inaccessibl less the operatoı under the car. average motorist takes care of hi car does not enjo ting under the c unless absolutely essary. Point must be reached odically are apt neglected, where the oiling was not too much of a task, they would receive re attention. If a rear axle on a practically new car grinds or the first step is to introduce some grease into the differential unless the noise is so pronounced that it is evident it must be c by lack of alignment or poor meshing of the driving gears.

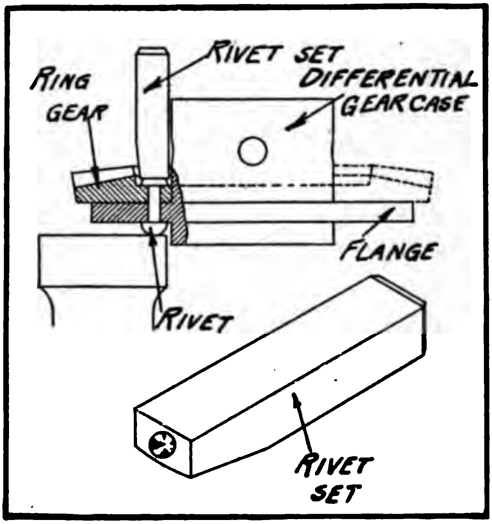


Fig. 392.—How to Rivet Driving Gear to Differential Gear Case.

ɔst differential housings have a removable cover plate leaving ening through which grease may be introduced when neces- It is somewhat of a task to remove this cover, so many makers le a plug through which the spout of a syringe or grease gun ›e introduced to advantage.

very practical form of grease gun is shown at Fig. 393, A. .s filled with the grease used for oiling the differential gears awing the plunger to the extreme outward position and re- ıg the threaded closure member to which the spout is at- l. This makes it possible to pack the grease in the pump . after which the cover is screwed back. In order to force eavy lubricant ı simple ratchet ınism is provided, d by a handle, provides consid- leverage, this ng against a se- f ratchet teeth on .unger rod of the . By grasping ımp as shown it sible to empty the ;e with very lit- ertion by moving rigger-like lever sh in the plunger place the grease. forms of grease have a threaded er rod, which ɔe screwed in the barrel to force out the grease; some use ·essed air.

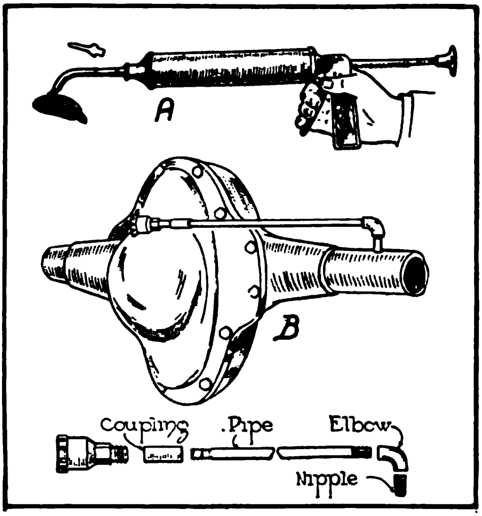


Fig. 393.—Methods of Lubricating Rear Construction.

here grease cups are fitted in important but inaccessible places nscientious operator is obliged to reach under the chassis and .e uncomfortable positions, not to mention the ever present ır of soiling the clothing. An easily made and inexpensive

device is shown at Fig. 393, B, which will bring the grease cup to a point where it may be easily reached. The material nece consists of a piece of ordinary one-eighth inch gas pipe, an el coupling, and a short nipple which are joined together as indic To install the device the cup is removed and the distance meas from the part to be lubricated to the most convenient point w the grease cup is intended to be placed. Practically all com sion grease cups are provided with a one-eighth inch standard gas-pipe thread. When the grease cup is removed from the there should be no difficulty in placing a nipple in the opening by the withdrawal of the grease cup. The elbow is attached to nipple, after which the piece of pipe, which has been cut the pr length and threaded at both ends is screwed into the elbow at end and the coupling screwed on at the other. The grease cu then screwed into the female thread at the end of the coup Care should be taken to fasten the pipe at the grease cup en means of a metal clip, as if it is not securely fastened to some of the axle it will be apt to break off due to vibration. It sh be remembered that it is necessary to fill the entire length of with grease before any will reach the bearing point, therefo is important that the grease cup be refilled a number of time make sure that grease will reach the bearings.

No part of the automobile is exposed to more dust and dirt the operating linkage of the hub brakes. Upon the majorit automobiles no means are provided for effective lubrication of t parts. Any looseness of the bearing pins causes a disagree rattling due to rapid wear of the dry bearings. The usual me of lubrication is by a squirt can, oil being applied to the cre between the moving and stationary parts with a hope that it find a way between bearing surfaces. It is well to wipe off sur lubricant from the outside of the joint, as this only serves to tract and hold road dust.

Methods of Retaining Lubricant in Wheel Hubs and Di ential Housings.—The retention of lubricant and exclusion of is one of the problems confronting the designer of automobile that can be solved in a number of different ways. It is impo to prevent the escape of grease from the differential housin

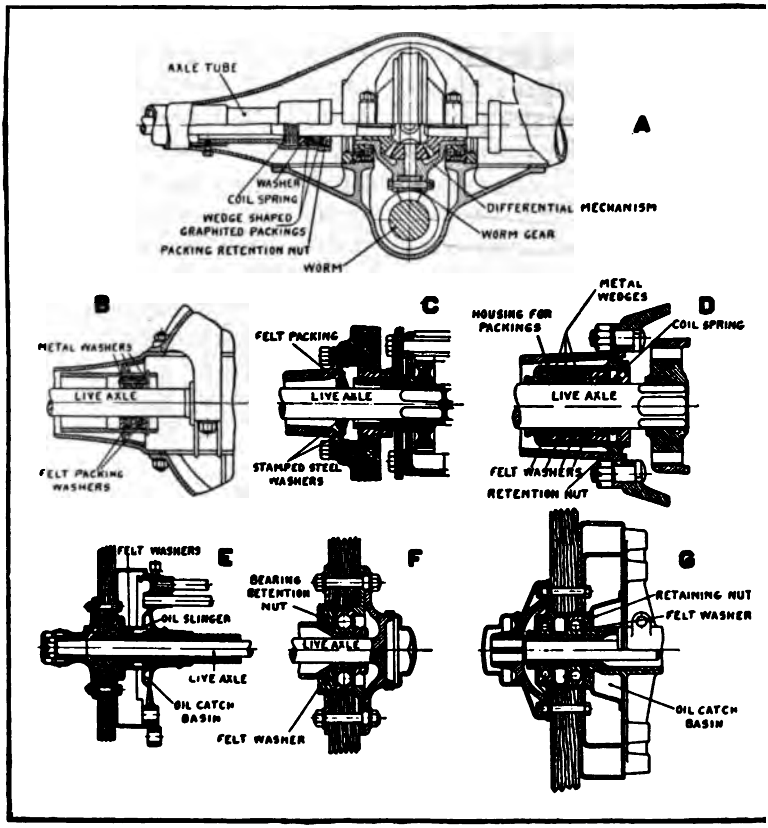


Fig. 394.—Showing Typical Methods of Retaining Grease in Differentia Housings and Wheels.

cause it will accumulate on the internal brakes and reduce the efficiency. While it is difficult to overcome leakage due to an e cessive supply of lubricant, if reasonable precautions are taken this respect, an axle housing may be made practically grease tigl A number of oil-retaining methods selected at random and knov to give satisfactory results in practice is depicted in accompan ing series of illustrations.

A worm gear drive axle is more apt to lose oil because this for *of gearing demands* more lubricant and of a more fluid nature t

that ordinarily supplied to bevel gear driven axle housings. ingenious application of a self-tightening stuffing box is used in construction outlined at Fig. 394, A. The tubular housings t enclose the live axles project into the differential case and have enlargement at the end closed by a packing retention nut. T bears against one wedge-shaped graphited packing which fits taper seat of the other packing element. As a certain amount wear is unavoidable as the shafts revolve inside the packings, s method of keeping the packings properly seated is necessary. T is accomplished by a coil spring which holds the packings in i mate contact with the shaft. When the car rounds a curve a the lubricant is thrown to one side, the space between the sle tube and housing acts as a pocket and retains the oil, allowin to flow back to the bottom of the housing when the car is no lon tilted.

In a number of cases, felt washers form an effective barr against passage of oil along the shaft, though when these are ployed, a supplementary packing member is utilized at the wh end of the axle. Two felt washers firmly held between steel cla ing plates may be fitted as at B, or a special composite member outlined at C may be substituted. The packing member is incli as shown, so that the oil carried around by the axle will be flected back to the bearing housing.

The self-adjusting stuffing box arrangement shown at D is si lar in design to that outlined at A, except that more felt wash are used and metal wedges are depended on to keep the wash bearing against the axle. As in the other design, the pressure a substantial coil spring keeps the metal wedges in firm cont with the felt packings.

There is no better known or more effective method of keep oil from leaking out of the axle at the wheel end than the paten oil slinger invented by Weston-Mott engineers and depicted at The function of this member, which revolves with the wheel, is throw the oil which leaks by the felt washers into an oil catch b cast integral with the brake-band carrying plate. A bent pipe the bottom of this chamber allows the oil to drain off to the grou clear of the brakes and tires.

The method shown at F involves the use of a tapering axle hous-
g tube and a bearing retention nut carrying a liberal felt washer
an annulus machined therein. Should any oil pass by the felt
asher, that member must be renewed. The construction outlined
G is a combination of felt washer to restrain the oil and a catch-
isin to hold any lubricant that escapes past the felt packing. The

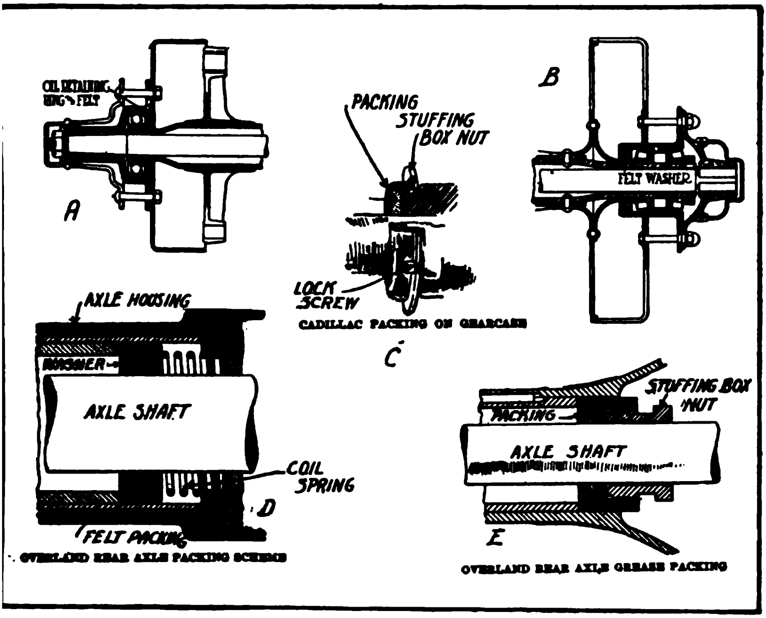


Fig. 395.—Miscellaneous Grease Retaining Methods.

l container is attached to the casting used to support the brake
sembly. This system is used by the Salisbury Wheel & Mfg.
ompany.

The methods of grease retention shown at Fig. 395 are similar
those previously described. At A, a simple oil retaining ring
id felt packing are believed sufficient. At B, we have a modifica-
m of the idea shown at A, in which a more liberal felt washer is
ed which is held in a pressed steel retaining member. The stuff-
g box idea as shown at C is more often used on transmission gear

cases than on rear axles, but as the gear case is sometimes combined with the differential housing a packing of this form may be found on the rear axle. In order to prevent oil leakage it is necessary to screw up on the packing ring to compress the felt more tightly against the shaft. Before the adjusting member can be turned it is necessary to release the locking screw which must be replaced when the stuffing box has been properly tightened. The automatic stuffing box shown at D is used on some Overland rear axles. This consists of a substantial felt washer held between steel plates, a constant pressure against the washer being exerted by a coil spring. Other Overland models have the grease packing shown at Fig. 395, E. This is the form of stuffing box widely applied in marine use which must be taken up from time to time to compensate for wearing of the felt packing member. If grease escapes from the end of the axle shaft and accumulates on the wheels or tires, this may be taken as a sure indication that the felt packing is worn and must be replaced with new washers. It is not only desirable to keep the grease in the axle on the score of cleanliness, but also on that of economy of lubricant.

Types of Axle Bearings.—At the present time most automobile axles are equipped with anti-friction bearings of various types. These may employ either ball or rollers as load carrying elements. Two common forms of ball bearings are shown at Fig. 396, A and B. The cup and cone type shown in part section at A has been widely applied to the front wheels of light and medium priced pleasure cars and in some cases as a support for the sides of the differential. It is an angular contact form and requires adjustment. The bearing at B is an annular form intended only for supporting radial loads. It is a non-adjustable unit and when it wears it must be replaced with a new bearing.

The roller bearings used are in three main forms, that shown at C using straight rolls of solid steel, that at D using solid taper rolls and the forms at E and F which use straight, hollow rollers. The taper roller bearing and the cup and cone type ball bearing are of the "take up" type. This means that they must be adjusted for smooth running and all lost motion eliminated after the members they support have been assembled in the rear construction

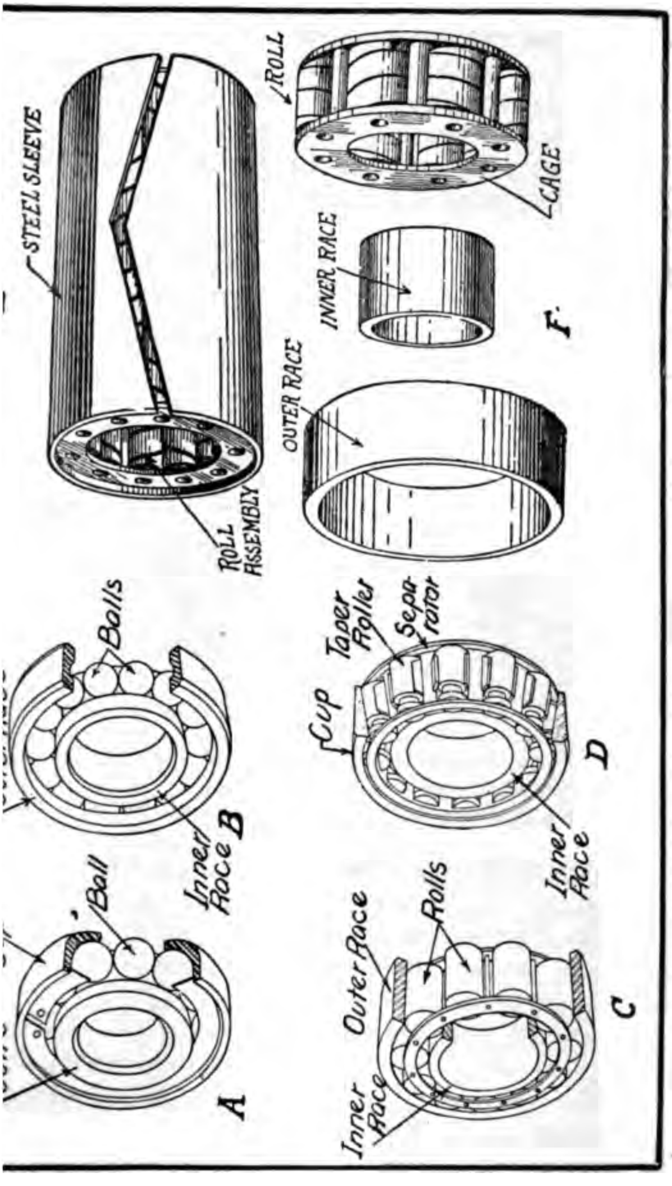


Fig. 396.—Outlining Conventional Types of Ball and Roller Bearings.

tion. Both of these bearings have angular load lines which adapt them to resisting end thrust and radial load in combination. The annular ball bearing shown at D is capable of withstanding slight end thrust but is not generally sold for this purpose. The straight roller bearings have no end thrust capacity and when used in an axle must be supplemented by other bearings, usually ball thrust washers, that are adapted to resist the end thrust.

The Hyatt bearings, which are shown in the standard form at E, and the high duty type at F, have rolls made in the form of close wound spiral springs. This bearing has been very widely used, as

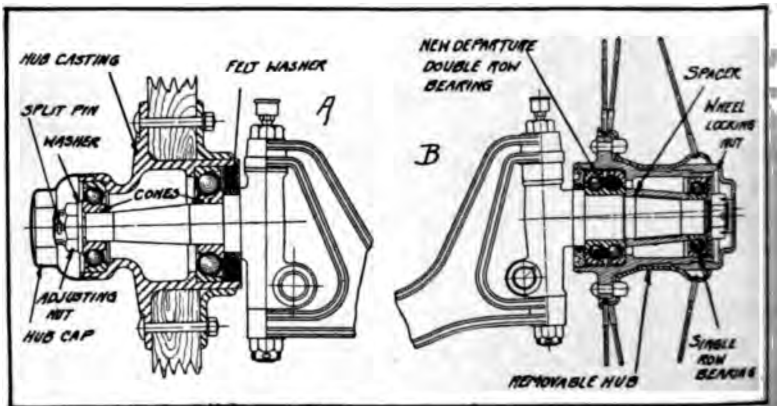


Fig. 397.—Illustrating Two Methods of Mounting Front Wheel Hubs on Ball Bearings. A—Cup and Cone Bearing. B—Unit Type Non-Adjustable Bearings.

is also true of the Timken roller bearing shown at D. In the standard type Hyatt bearing the long rollers are intended to bear directly on the shaft they support. In the high duty form the alloy steel rolls are shorter and are provided with accurately ground inner and outer race rings.

Two applications of ball bearings to front wheel hubs are shown at Fig. 397. That at A uses Radax bearings which are of the angular contact cup and cone type. The method of adjustment is clearly outlined. The wire wheel hub shown at B is mounted on a combination mounting consisting of a double row bearing clamped

firmly in the master hub shell and also tightly held on the wheel spindle. The single row bearing on the outer end of the wheel spindle is not called upon to take any end thrust as the double row bearing is. If any looseness develops in the hub mounting shown at A, and upon examination the bearing components are found to be in good condition, the trouble may be easily corrected by screwing up on the adjusting nut to bring the cone of the outer bearing more firmly in contact with the balls which in turn push the outer race member and the hub it supports over towards the steering knuckle and take out any lost motion which may exist between the parts of the inner bearing. When looseness develops in the hub of the form shown at B, the trouble is usually due to the locking nut on the end of the spindle becoming loose and allowing some clearance between the spacer and the bearing inner races. The remedy for this condition is to tighten up on the nut to bring the bearing races and the spacer into more intimate contact. In examining bearings of the non-adjustable form it is imperative to have these perfectly clean as small particles of dirt will make them run harshly. The impression a dirty bearing will give is just as bad as a worn one will produce, so before a bearing is condemned it should be thoroughly cleaned.

Removing and Installing Ball Bearings.—Many anti-friction bearings are damaged in removal or during application when repairing mechanism in which they are mounted, but this results more from ignorance of their nature than deliberate intent to damage them. A common cause of bearing failure is noted when they are driven in place by blows from an ordinary machinist's hammer applied directly to the bearing face or through the medium of a steel drift or blunt cold chisel. Ball bearings should never be driven in place or removed by use of steel or other hard metal tools because the race members may be permanently sprung or deformed by this treatment. Wherever the construction permits, which is true of most automobile applications, bearings should be removed by direct application of pressure to the part that is tightly fitted. When a bearing is mounted in a wheel hub, as indicated at Fig. 398, a simple form of wheel puller can be employed to advantage. This is a substantial casting of malleable iron or bro-

made approximately the same shape as the hub cap, threa side to fit the hub and having a substantial set screw at l inch diameter passing through the threaded boss at the cent screw should be long enough to pull the wheel and bearing off the spindle or axle tube. A shouldered plug of steel wit pression drilled in to locate the screw point may be pushed hollow tube to centralize the screw pressure. In use, th

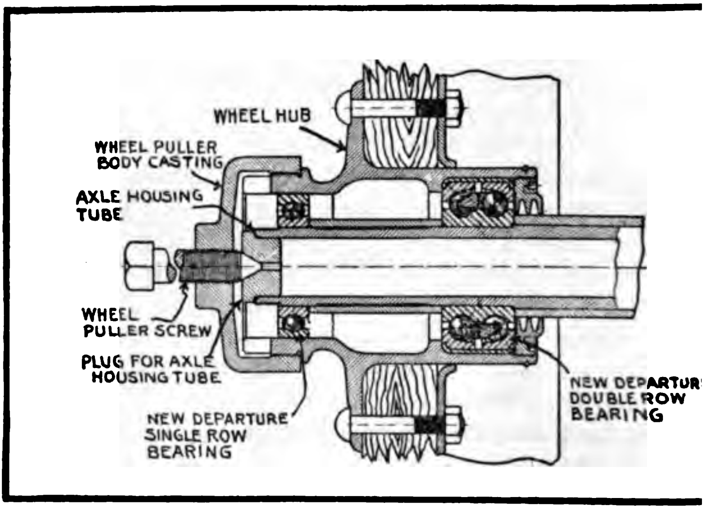


Fig. 398.—Showing Construction of Simple Wheel Puller for Re Wheel Hub From Full Floating Rear Axle.

puller casting or wheel is kept from turning, so that as th advances, it pulls off the wheel and the bearing it contains.

A modified form of puller having two arms and a cro that can be used when a bearing cone must be removed f axle or spindle is outlined at Fig. 399, A. An attachment mit it to remove a bearing of the unit type such as a si double row annular without exerting any pressure on the outer race is clearly depicted at Fig. 399 B. This consis split casting adapted to be clamped loosely around the sha of the bearing inner race and any pressure exerted to rem

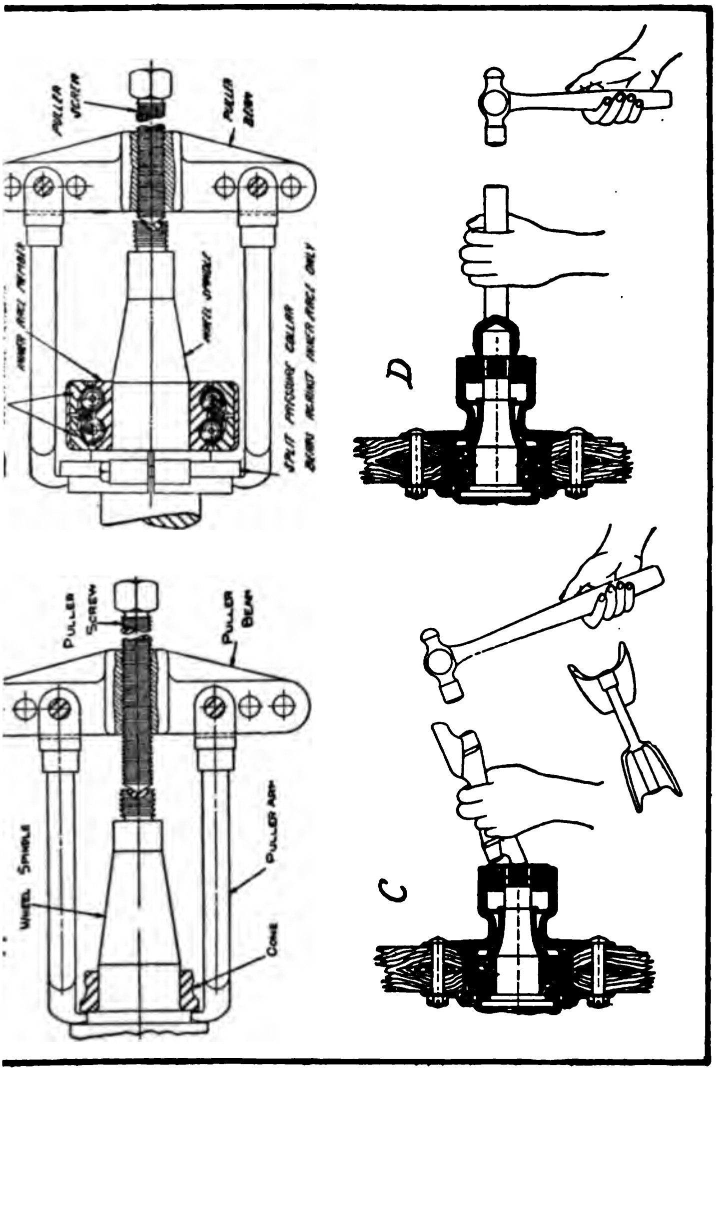


Fig. 399.—Methods of Removing and Installing Ball Bearings Without Damaging Them.

bearing is applied directly against the member which is fit on the shaft. When any form of hub or bearing puller start the member to which it is applied by direct pull, it may be accelerated after the screw has been tightened suf to place the parts under a certain initial tension by a fev well directed hammer blows on the beam or main body device.

In all cases where possible, the pressure applied to r bearing or part should be exerted directly against the port

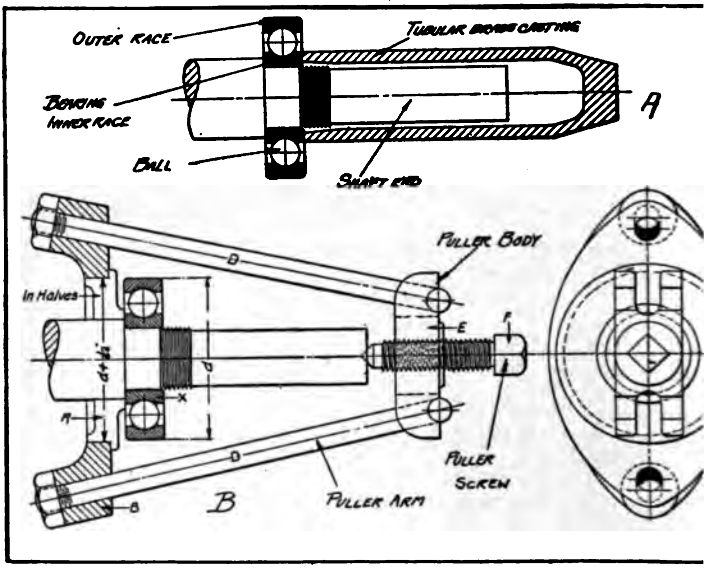


Fig. 400.—Simple Tools for Ball Bearing Installation and Rem

is a tight fit on the shaft or in the housing. In most cas the inner member of the bearing that is a force or press fi shaft, the outer race member is usually a push fit in the and may be easily removed. If it is necessary to force the off with a series of blows, always use a brass or hard babbi bar or drift between the bearing and hammer, or even a hard maple, hemlock or oak. Do not direct all the blows one point on bearing as this tends to cramp it and will

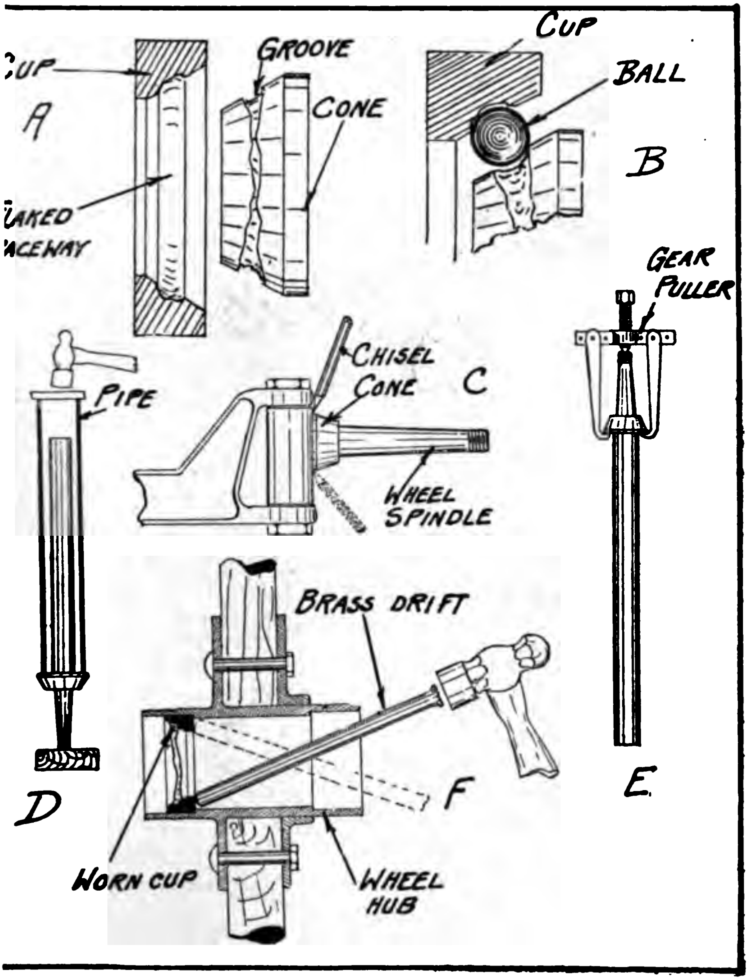
er to drive off. Distribute them evenly around the entire cir-
:erence, always having successive blows at points diametrically
site. When driving bearings in place, it is always best to use
form of soft metal yoke member as shown at Fig. 399, C, or
lar section piece as shown at Fig. 399, D. With either the
or the other tubular form the hammer blows are distributed
ly and the bearing is driven in place without injury to either
; or bearing components. When a double fork member is used,
ɜnd can be made to drive against the inner race member while
ɩther can be spread enough to fit the outer race if desired.
'he method of driving an inner race in place shown at Fig.
A, is recommended by the Hess-Bright Bearing Company.
is a cast brass tubular member proportioned about as shown.
eable iron or any relatively soft material will answer in place
ɩe brass. It is possible in many cases to make very satisfac-
bearing installing members of standard brass pipe. Most ball
ings have the size number stamped on the side of the inner
When installing Hess-Bright bearings always place the un-
bered side on first when driving in place. The tool shown at
355, B, is recommended for removing bearings. The essential
t to observe is to exert a steady, uniformly distributed pull on
back side of the inner race in pulling that member off the
t, instead of against the outer race and the balls. The method
peration is very simple, the inner split ring A is placed back
ɩe inner race X. The split ring is held together by a solid outer
B placed on its circumference having holes for the straddle
ı D, directly over the joints in ring A. The outer ring B is
ɩected to the cross bar E by the two straddle bolts D. Cross
E is supported by the set screw F entering the shaft center
and the bearing is easily withdrawn from the shaft by apply-
a wrench to the set screw.
:n adjusting cup and cone ball bearings or taper roller bearings
necessary to make the adjustment very carefully in compen-
ɩg for lost motion that exists in the assembly. The condition
he bearings may be determined without difficulty when these
used in the wheels by jacking up under the axle to raise the
el clear of the ground and thus relieve it of car weight, then by

grasping the wheel rim at opposite points and attempting to the wheel. Any looseness in the bearings can be detected b motion between the wheel hub and spindle. Care should be not to confound this lost motion with looseness in the st knuckle supporting pin.

In taking up lost motion when any type of adjustable b is employed, considerable judgment must be exercised in sc up on the adjusting member not to get this up too tightly a pose an injurious end pressure on the balls or rollers. An pressure that will stress the bearing parts dangerously w make much difference in the wheel resistance when turned by though when the car weight must be sustained at high sp when going around corners the resistance will be increased ally and bearing endurance reduced in proportion. A safe follow is to take up the wear by screwing in the adjustm enough so the "shake" or looseness will be eliminated and y mit the wheel to "spin" for a few revolutions when given tial impulse. Many motorists and even inexperienced me commit the error of adjusting bearings of the "take up" t loosely. This is not desirable, any more than fitting pa tightly together is. Always lock adjustment nut firmly i when proper adjustment has been secured.

In some gear boxes and axles, the bearings are shim ad A number of thin washers of sheet brass may be interposed b the bearing cup and the retainer cap. When taking down sembly of this nature always keep the shims from any l box together and tagged for future identification to insure t adjustment made in the factory will be maintained after reas in the repair shop. If the bearings are loose for any reas thin shims about .005-inch thick to the others, until there is preciable lost motion and yet no binding between bearing

A word of caution is necessary to the inexperienced n when tightening adjustable bearings of the cup and cone typ first thought when looseness is detected is to tighten them by ing the cones into closer engagement with the balls and thu these members more tightly against the bearing cups. This never be done without examining the condition of the cu



. 401.—Illustrating Depreciation in Cup and Cone Bearing at A and B and Method of Removing Cone from Wheel Spindle at C. Use of Drift in Driving Out Anti-Friction Bearing Cups from Wheel Hub Outlined at F.

ball and separator assembly. If a groove has worn in the cup **cone, as shown at** Fig. 401, A, due to flaking away of the metal **er load, nothing** will be gained by adjusting the bearing

bringing the cone into closer engagement. This will cause to ride on the sharp edges of the grooves as shown at Fig which will result in rapid destruction of the entire bea cause either a broken ball or some of the flaked particle: will get between the bearing parts. When adjustable bea

Fig. 402.—Wheel Removed from Motor Truck Front Axle to Arrangement of Bearings on Steering Spindle.

come worn it is necessary to replace both worn cup anc well as entire new series of steel balls.

When it is necessary to replace a bearing the old one removed, and while a number of tools has been descri work very well on modern cars, some difficulty will be ex

those of early design because no provision was made for easy ıoval as is now the case. The easiest method of removing a bear- cone when it is forced on a wheel spindle and no opportunity is sent for using a special puller is shown at Fig. 401, C. A sharp l chisel is used, this being driven between the cone and the ılder against which it is forced on alternate sides, first above, ı below, and then on either side until the cone has been worked of the wheel spindle. Similarly a ball or roller bearing cup t is a tight fit in a wheel hub may be driven out by careful ap- ation of a brass drift as shown at Fig. 401, F. The hammer should never be directed at any one point of the cup because pressure is applied at one point only it will cramp the cup in b and any further hammering after the cup is "cocked" will rve to make it more difficult to remove. The method of re- g a cone from a long shaft by a piece of pipe as at B, and by r puller as at Fig. 401, E, is generally understood by repair- If the cone resists either of these methods, it can be forced der an arbor press.

brication and Enclosure.—Ball bearings do not require the nual application of lubricants that is called for by plain bush- , and, to a lesser degree, by roller bearings, but this does not n that lubrication can be neglected or done carelessly. The rtant point to observe is that none but pure mineral oils or es be used, as any that show traces of acid or alkali, or that become rancid from oxidization will cause etching and rough- of the highly finished surfaces of the balls and races. Lu- nts best adapted range from light machinery oils, used in high speed bearings, such as fitted in magnetos, lighting gen- rs or starting motors, to the viscous grease utilized in those jected to heavy loads and revolving at low speeds as wheel bear- s or differential bearings. Wherever the bearing can be im- sed in a bath of oil and properly protected from water and grit ghter oil can be used, but when the bearings are housed where t or water may get in, then the use of ample quantities of vis- s lubricant, such as vaseline or other mineral grease that is from acid prevents the foreign matter working in between the s and races. Ball or roller bearings are generally enclosed in

such a manner that there will be no opportunity for dust, water to enter, and if this function is properly performed t sure will also be tight enough to prevent escape of oil.

Importance of Proper Maintenance Emphasized.—Desp extreme care taken in manufacture, bearings of the leading sometimes fail in service, and the motorist or average deale ready to condemn that which he does not fully understand.

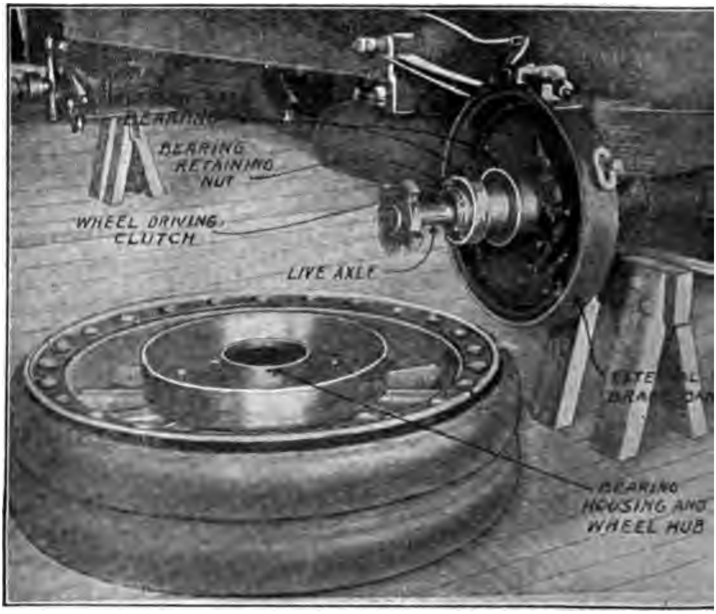
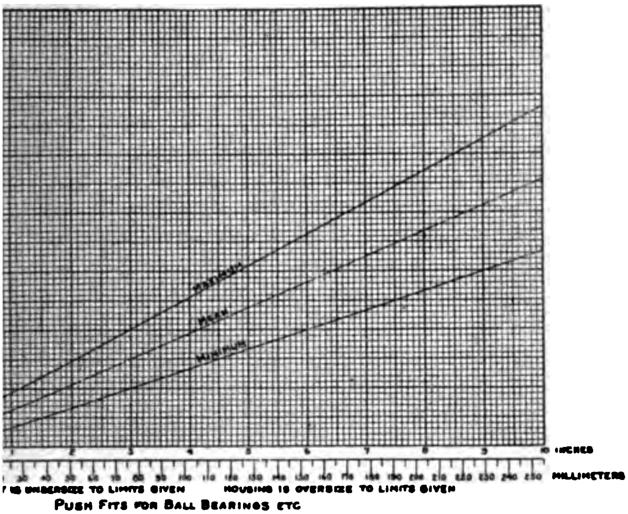


Fig. 403.—Wheel Removed from Full Floating Axle of Motor Tr Show Method of Ball Bearing Installation.

utes the cause of failure to careless workmanship or the poor materials on the part of the producer, whereas the tru often due to conditions which are entirely within the user's c A ball bearing must have a certain amount of running cle but in the leading types this is much less than in a plain b it being common practice to allow a radial freedom never g than .001-inch. In connection with this, in single row radia ings an axial freedom or end play of the inner race relative

owed, this varying with the size of the bearing between :s of .0005-inch to .005-inch for new bearings. Thus a ıade and installed ball bearing will not deteriorate in d sense of the term as applied to plain boxes; that is, e no reduction of diameter or increase in bore. If there sive amount of axial or radial motion the cause is ad-' some abrasive between the components of the bearing



404.—Chart Showing Allowances for Push Fits for Ball Bearings, etc.

oading. As is true of any bearing, the amount of wear l upon the cutting power of the grit, the pressure the e subjected to, and the amount of time the foreign mat-:en the working surfaces.

re places where a certain amount of dirt and metallic e always present. For example, many cases of trouble e and transmission case bearings have been definitely e presence of minute particles of metal ground off from

the gears, or sand loosened from the interior of the gear rear axle housing castings. In sliding gears, especially whe ated by an inexperienced person, there is a constant clasl the pinions in changing speed, which tends to loosen parti metal from the teeth. These fall into the lubricant, an churned around and often find their way into the ball races.

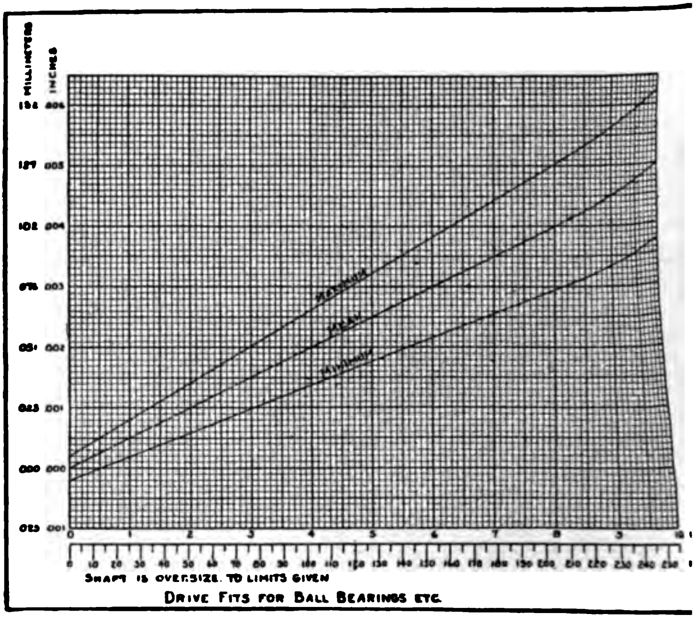


Fig. 405.—Chart Showing Drive Fits for Ball Bearings, et

rapid failure of the bearing is the inevitable consequen importance of proper mounting has been so firmly impress the automobile manufacturers that but little trouble is cau improper installation in cars of reputable makes. Hence forced to consider the user in many cases when analyzin of bearing failure.

There is a condition that is beyond the control of th facturers of either the bearings or the mechanism to wh are fitted, and that is the use of impure oils, and careles washing the running gear and other parts of automobiles.

Table of Standard Fits.

...its in Housing ...rsize. (Push Fit)		Standard Fits of Shaft Shaft Undersize. (Push Fit)				Standard Fits of Shaft Shaft Oversize. (Drive Fit)			
Housing Diameter		Bearing Bore		Shaft Diameter		Bearing Bore		Shaft Diameter	
Maximum	Minimum	M/M	Inches	Maximum	Minimum	M/M	Inches	Maximum	Minimum
1.1830	1.1824	10	.3937	.3936	.3930	10	.3937	.3941	.3938
1.2619	1.2612	12	.4724	.4721	.4716	12	.4724	.4729	.4726
1.3813	1.3806	15	.5906	.5906	.5897	15	.5906	.5909	.5906
1.5006	1.5000	17	.6693	.6693	.6688	17	.6693	.6697	.6693
1.8758	1.8751	20	.7874	.7870	.7860	20	.7874	.7880	.7874
1.6875	1.6868	22	.8661	.8656	.8650	22	.8661	.8667	.8661
1.8758	1.8751	25	.9843	.9837	.9831	25	.9843	.9848	.9843
1.8846	1.8838	27	1.0630	1.0626	1.0617	27	1.0630	1.0642	1.0630
1.7328	1.7320	30	1.1811	1.1805	1.1799	30	1.1811	1.1818	1.1823
1.8516	1.8507	35	1.3779	1.3773	1.3766	35	1.3779	1.3807	1.3781
2.0484	2.0476	40	1.5748	1.5741	1.5739	40	1.5748	1.5756	1.5750
2.4423	2.4413	45	1.7716	1.7708	1.7703	45	1.7716	1.7727	1.7719
2.5661	2.5653	50	1.9685	1.9676	1.9668	50	1.9685	1.9697	1.9689
2.1812	2.1803	55	2.1653	2.1644	2.1636	55	2.1653	2.1665	2.1657
3.0484	3.0473	60	2.3622	2.3612	2.3603	60	2.3622	2.3637	2.3627
3.5433	2.5441	65	2.5590	2.5575	2.5570	65	2.5590	2.5605	2.5596
3.9381	3.9370	70	2.7559	2.7548	2.7539	70	2.7559	2.7570	2.7560
4.3330	4.3318	75	2.9527	2.9515	2.9508	75	2.9527	2.9540	2.9530
4.7270	4.7258	80	3.1496	3.1486	3.1473	80	3.1496	3.1518	3.1504
4.9308	4.9303	85	3.3464	3.34505	3.34395	85	3.3464	3.34805	3.34720
5.1208	5.1194	90	3.5433	3.54205	3.54075	90	3.5433	3.54545	3.54455
5.5147	5.5132	95	3.7401	3.73855	3.73745	95	3.7401	3.74205	3.74115
5.9060	5.9060	100	3.9370	3.93545	3.93425	100	3.9370	3.93905	3.93815
6.3004	6.2997	105	4.1338	4.13215	4.13095	105	4.1338	4.13605	4.13495
6.8903	6.8946	110	4.3307	4.32905	4.32775	110	4.3307	4.33285	4.33185
7.0903	7.0894								
7.4841	7.4828								
7.8780	7.8760								
8.2730	8.2696								
8.4660	8.4650								
9.0620	9.0607								
9.4557	9.4544								
9.8476	9.8484								
10.4430	10.[illegible]								

ig. 406.—Table of Standard Fits for Ball Bearings.

lure of wheel bearings have been directly attributed to by the indiscriminate application of a stream of water lbs. pressure per square inch which is not uncommon y water mains, to the parts of the car in which they are The water finds its way into the bearings, causes the hed surfaces of the balls and races to rust, and the ex- racy in manufacturing and the care of installing is preventing breaking down of the bearings. The user liberately clean off the parts of the power plant with a vil effects of water at this essential point having been his attention too forcibly by troubles in carburetion and t the same person who is so extremely careful of the

motor, will spray other parts, fully as important in the duties they perform, with a stream of water under high pressure.

That rust is absolutely destructive to ball bearings has been thoroughly proven in so many instances that the contention cannot be questioned. Of what value is extreme accuracy of finish of the balls to .0001 of an inch if the advantages accruing are to be mitigated by deposits of rust of much greater thickness than the limit established in manufacturing. Such a condition can be as easily recognized by the novice as by the most expert for even if the bearing has been cleaned so that no ferric-oxide is visible to the eye, there will be a number of pits or depressions on the various parts of the bearings, especially at the highly finished ball surfaces which are clearly evident. While these minute irregularities are sometimes caused by overloading and the flaking off of the metal which results from this condition, if due to causes other than rust and acid, the roughness would be confined to the ball tracks, whereas excoriations resulting from chemical action will be in evidence on all parts of the bearing.

It is a known fact that many oils and greases contain acids or alkalis, either as a necessary component of their chemical composition (as in some animal fats that contain stearic acid); as a part of some filler used to adulterate the oil or alter its viscosity, and sometimes as a residue of some of the processes of purifying that obtain in refining from the crude product. The presence of acid in lubricants will cause an etching with irregular edges, in contrast to the clearly defined rust marks. A good lubricant for bearings is a slush made of pure vaseline and lighter mineral oil this being heated to make its viscosity less and enable it to penetrate all parts of the bearings, no matter how minute the spaces. When the bearing has been dipped in this and allowed to remain long enough to permit the oil to reach all parts, it is taken out and allowed to cool and the surplus lubricant is wiped off the outside. Such a mixture will stay in place and will not run out like lighter oils, and at the same time its viscosity is not so high that it will produce unnecessary friction.

How Bearings Should Be Cleaned before Examination.—Another point that can be criticized is the common method of clean-

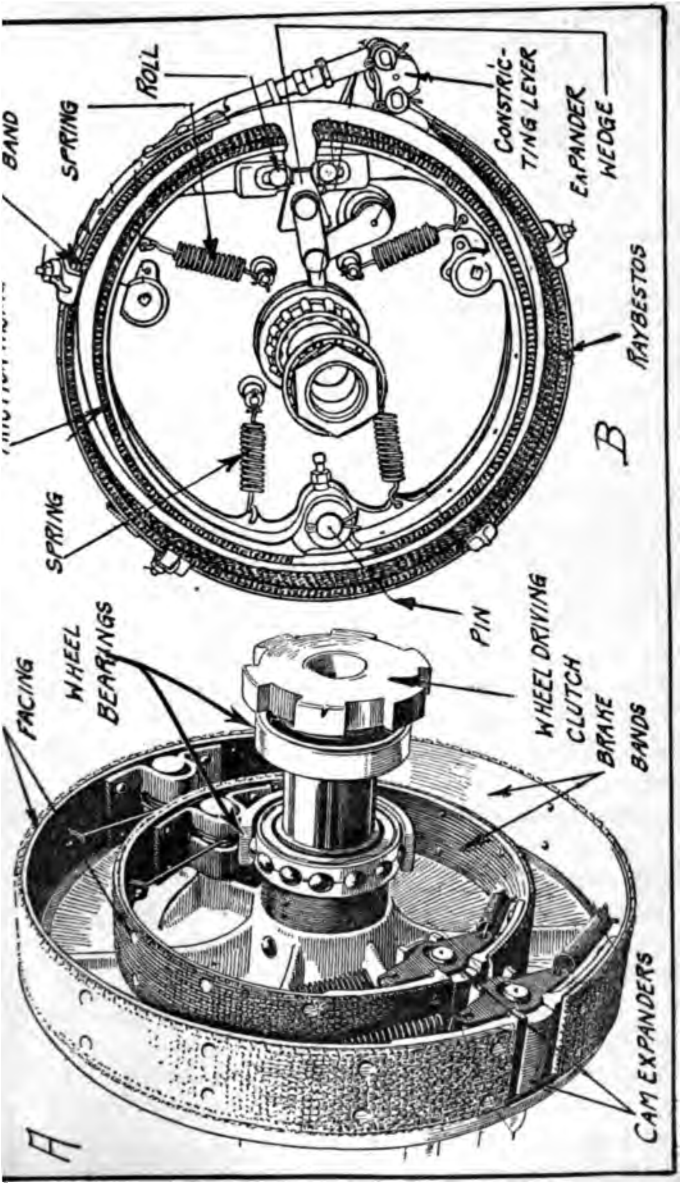


Fig. 407.—Illustrating Construction of Internal and External Brakes.

ing ball bearings in the average car repair establishment or ma- chine shop. They are often dipped in dirty gasoline in which di gears and other parts have been previously cleansed, and this ma terial is often so full of metallic particles, that as soon as it i stirred up enough to disturb the sediment, instead of having clean bearing, one has filled it with deleterious substances witho knowing it. A simple solution of common washing soda and h water, such as is used in many shops for cleaning greasy parts a assembled bearings at the completion of the manufacturing proc offers important advantages. This can be easily made by taki about a handful of the soda to the pail of boiling water. Th cleaning agent should be kept nearly at boiling point while in us The bearings are placed in a wire basket, or hung on a wire an dipped in an alkali solution a few times to remove all dirt; the they are immersed in clean kerosene and given a swirling moti to have this material thoroughly clear out all traces of the sod The bearings should not be allowed to remain in the wash mo than a few minutes at the most, and a few dippings are all th is necessary to clean them out thoroughly and cut all the hard a rancid grease or remove any metallic dust present. After examin tion of used parts, if the bearings are clean, the surfaces brig and there is not too much looseness, they are in good condition.

A little attention given to careful inspection and consistent l brication of bearings will be amply compensated for by the i creased service obtained and augmented efficiency. The import rules upon which efficient ball or roller bearing service is bas can be summed up in a very few words.

First, inspect the bearings from time to time and see that th are clean, and the lubricant does not contain foreign matter, pecially in gear boxes and differential casings.

Second, be careful in supplying new lubricant that it is f from acid, alkali, vegetable or animal fillers or other deleter substances.

Third, when installed in exposed parts of motor cars, be car when washing not to direct the stream of water directly ag bearing housings of the parts.

Brake Forms and Adjustments.—The brakes used to re

otor car motion are a part of the car that are not only used, but hich are often apt to be abused. Brakes are of two general forms, ie internal type as shown at Fig. 407, A, and the external contricting band type as exemplified by the outer brake of the assemly shown at Fig. 407, B. Internal brakes may be either metal hoes that are in metallic contact with the brake drums attached o wheel hubs when applied, or members faced with some asbestos rictional material which can be replaced when worn. The internal rakes may be cam expanded as the forms shown at A are or may e worked by a wedge expander as the internal brake expanders f the assembly shown at B. As a rule no adjustment is provided n cam expanded brakes in the brake construction itself. On exernal brakes, means of adjustment are usually included.

When full movement of a hand lever or pedal fails to engage n internal brake the first step is to remove the wheel to make sure hat the slipping is not due to deposits of grease or to worn brake acings. If the brake facing is clean and not worn unduly, the only ractical means of adjustment is by tightening up on the operating nkage. This is easily done by shortening the brake control rod. n the construction shown at Fig. 408, B, this is easily accomlished by turning up on a turnbuckle set into the brake rod. In ll cases, even if the turnbuckle is not provided, the clevis at the nd of the rod may be screwed up further on the rod which has he same effect as shortening the rod by a turnbuckle would have.

Care should be taken in adjusting brakes by altering the length f the brake rod to have the brakes on both wheels take hold at he same time. In the construction shown at Fig. 408, A, this may e done by unloosening the clamp bolts and setting the lever operting the right brake at the proper point in the slot of the master ever which also operates the left brake. On an external brake of he form shown at Fig. 408, C, the means of adjustment is readily erceived. With an external constricting brake it is merely necesary to reduce the circumference of the brake band by screwing p an adjustment to provide for minor depreciation of the brake ning.

On the Overland cars, when it is desired to adjust the brakes his is easily done by loosening a clamp bolt passing through the

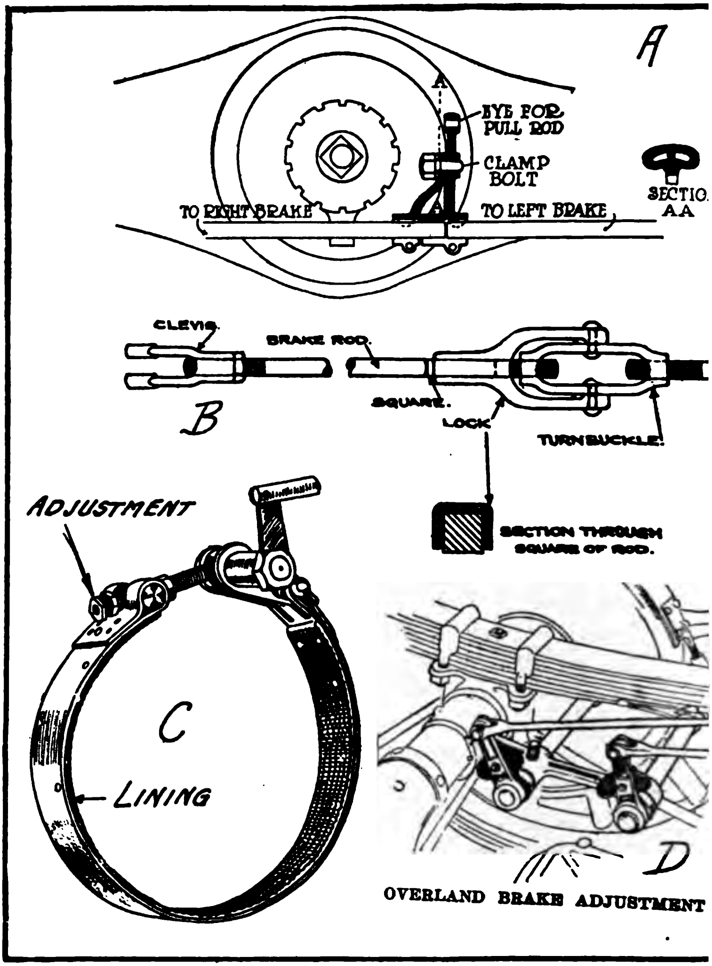


Fig. 408.—Showing Methods of Brake Adjustment.

lever to which the rod is connected and a slotted actuating pinned to the shaft employed in operating the brakes. It is necessary to rock the member over so that the brake parts nearly in engagement with the brake lever or pedal fully and then to maintain adjustment by screwing the operati

gainst the actuating member with the clamping bolt. Suf- ınge of adjustment is provided to take care of all brake other than that caused by worn brake lining. This method :ment is clearly shown at Fig. 408, D.

nding brakes are harder to fix than constricting brakes es- if they are of the solid shoe form and not provided with l material. The first step in examining the internal brake .ove the wheel which is done with a wheel puller as shown 409, A, if the rear construction is of the semi- or three- loating type. The full floating wheels may be removed as t Fig. 398. When the brake shoes are of the solid cast adjustment for depreciation may be made, as shown at D, providing some of the wear is at the point where the to spread the brake shoes apart. It is possible to put a e of hardened steel on the worn end of the shoe by using ns or flush headed screws. This spreads the brake shoes tly, the amount of spreading, of course, depending upon ness of the applied pieces and makes it possible to bring into positive engagement with the brake drums with but vement of the expanding cams. If the brake shoes them- e worn and it is not easy to secure new ones, the surfaces estored to efficiency by the application of thin sheet brass which material is firmly held in place by rivets and which ffect of restoring the worn segment or shoe to its original When pieces are applied to the brake shoes care should in refitting the wheels that the shoes do not bind against a when the brake leverage is released. Any high spots must be smoothed off with a file in order not to heat up the ım through useless friction when the car is in operation.

ical brake assembly is shown at Fig. 409, D. This is used models of the Cadillac car and consists of an internal ex- band and an external constricting one. Adjustment of ce brakes is made by turning the screw S which is on the he brake carrier until the part of the band opposite it is as close as possible to the brake drum without touching it. ust the nuts T on the eye bolt until the lower half of the ing just clears the drum. The nut V on the upper end

of the eye bolt is so adjusted as to bring the lever W to tion shown in drawing when the brake is applied. With t released the clearance between the lining and the drum sh be over 1/32-inch, and if more clearance exists it may be re(the set screw X in the rocker lever Z.

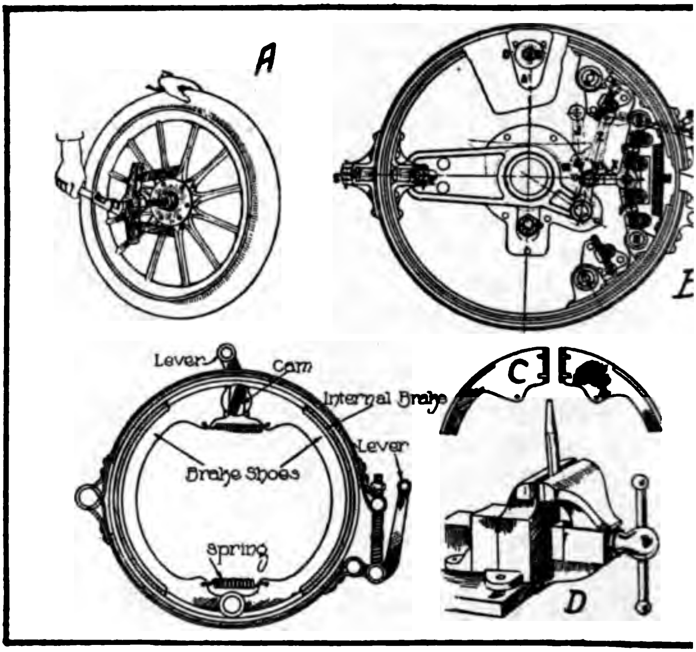


Fig. 409.—Hints on Adjusting Internal and External Brak

The internal brake is constructed to be adjusted for c between the internal band and the drum without remo\ wheels. Jack up the axle so the wheel will clear the gr permit revolving it by hand. A cover A will be found brake drum which can be removed by unscrewing the loc and turning the bolt to the left about a quarter turn u clamping bar D is released. Next rotate the wheel until tl ing registers with the adjusting screw E carried at the b of the brake band or at the point opposite the expandin

ıism. Turn the screw E until the part of the brake lining :e it is brought as close to the inner surface of the brake ıs possible without touching it. Turn the wheel until access ined to the six locking screws N and loosen these. This is ŕ bringing the opening in the brake drum opposite each screw ı and turning these with a suitable socket wrench. Then ıe two adjusting F F which have ıand threads on ıd and left on er until the cen- :he pin G stands :hree-quarters of ı back of an im- ŗ vertical line through the cen- f the two pins when the brake lied. With the released adjust ew I in the lever the stop screws until the lower ıper parts of the ɔand lining clear rum by about h. The three ırings M should ufficient tension l the brake band ys and against p screws K K so not rattle. It ortant that the M be locked

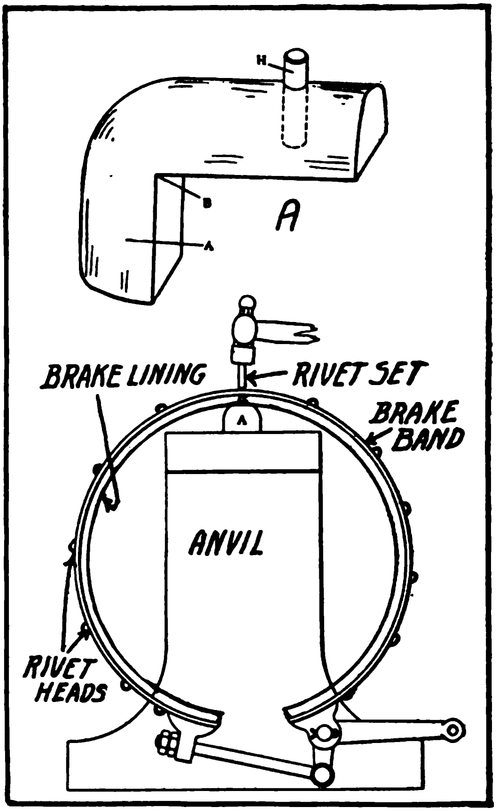


Fig. 410.—Simple Fixture to Facilitate Riveting Brake Lining to Steel Brake Bands.

ompleting the work, also that the cover in the opening of the lrum be replaced and fastened securely.

If the brake lining is worn it should be removed by chipping off the rivets and driving them out of the hole in the brake band. A piece of new lining is cut to the proper length and holes are drilled through it to coincide with those in the brake bands. The best method is to drill only two holes at a time and fit the lining carefully to one end of the brake band, then drilling in the next two rivet holes and after the lining is securely fastened in place to go on to the next rivets. It is important to use copper rivets having reasonably large heads that will not pull through the material and to countersink the material enough so the rivet heads will be firmly embedded below the surface so as not to come in contact with the brake drums. Some cases of slipping brakes have been traced to projecting rivet heads which did not permit the friction lining to come into contact with the brake drums.

A simple fitting which can be placed in an ordinary bench vise for riveting against is clearly shown at Fig. 409, B. This is an ordinary steel drift having a flat point of the same size as the rivet head. The fitting shown at Fig. 410, A, may be placed in a common vise or may be formed to fit the pritchell hole in an anvil. This piece may be made of mild steel though the punch H which is the same size as the rivet head can be made of tool steel. The body of the tool is flattened out on the under side where it rests on the anvil or bench vise top and is left oval on the top. A 3/8-inch hole is drilled in the top and tool steel punches of the form shown at H may be driven in place, some arrangement being made by which the punch may be driven out and replaced by a new one if it becomes broken or by one of smaller size if different rivets are used. A hammer and an ordinary rivet set are used to set the rivets as shown in the lower portion of the illustration. Copper rivets are easily headed up and neat heads may be formed without trouble. Never use iron or steel rivets for holding brake linings in place as projecting heads may wear grooves in the brake drums. The only remedy for grooved brake drums or members that have worn thin is replacement with new ones.

CHAPTER X

WHEELS, RIMS AND TIRES

Wood Wheel Construction—Houk Wire Wheel—Dunlop Wheel—Rudge-Wh worth Wire Wheel—Solid Tire Forms—Pneumatic Tire Constructior The Cord Tire—Rims for Pneumatic Tires—Tools for Tire Repairs How Tires are Handled—Small Vulcanizers—Shop Vulcanizing Equ ment—Supplies and Materials for Tire Repair Work—How Tires A Often Abused—Why a Tire Depreciates Rapidly—Water Rots Fabric Tire Tube Repairs—Replacing Valve Stems—Simple Casing Repairs Casing Repairs Made from Inside—Retreading and Rebuilding Tires The Dry Cure Method—Air Pressures and Carrying Capacity—Increa in Pressure by Heat—Carrying Capacity of Solid Tires—Metric Si and American Equivalents.

THE repairing of automobile tires is work that is usually l to the specialist whereas it can be very profitably done by the av age garage man if the necessary equipment is installed. The too supplies and apparatus needed are not expensive and the skill quired is much less than that needed to do the mechanical wo incidental to the repair of the engine and other vehicle parts. I fore considering the subject of tire repairing it may be well to view briefly the various forms of wheels and tire retaining rims which the tires are mounted. The tire repair processes will be co sidered from the point of view of those who desire to make or temporary repairs or take care of roadside accidents as well as cluding the more complete instructions necessary for making p manent repairs by vulcanizing processes. The equipment illu trated for doing the work is typical and has proven satisfactory practical use.

Wooden Wheel Construction.—The most popular form wheel to have received general application on all classes of au mobiles is the wooden spoke member of the same type as used gun carriages and for that reason termed the artillery wheel. Va *ous steps in making the* parts of the wheel and also the process

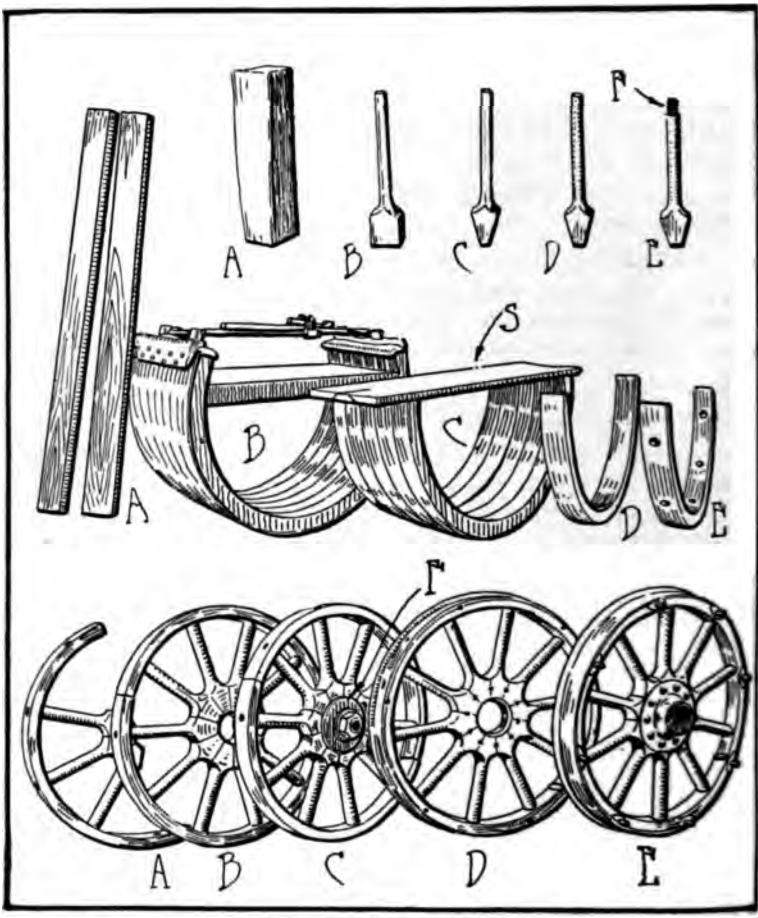


Fig. 411.—Showing Steps in the Construction of a Wooden Automobile Wheel.

wheel assembly are shown at Fig. 411. The spokes are turned from a billet as shown at A at the top of the illustration, the successive operation being shown at B in which the spoke has been turned approximately to size on a special turning lathe. The operation is called club turning because of the shape of the stock after it leaves the machine. The way the elliptical section is obtained is by having

ble centers and a cam motion to move the lathe heads in and ith respect to the cutters so as to get the section desired. The ›peration is mitering down the big end as shown at C and then ıg it over a planer to have the wedged shape end of uniform ıess, as outlined at D. The next step is to turn the tenon at pper end which fits into the wheel felloe.

ıe felloes are made by bending special pieces of stock (which een steamed) by a form of clamp and introducing a spacer ·en the two ends in order to secure the desired curvature. The blanks are kept in the form shown at B for a period of time ›laced in drying kilns. After removal from the kiln they are by a strip S for a time after which the strip is knocked off he felloes sawed to the proper form. The pieces D are planed ›th sides and also finished on the curved surfaces in order to :h them, followed by an operation to drill for the spokes with cial machine. The next step is to smooth the felloe member ılly on the inside, then to sand paper off the sharp corners :en the spoke holes. The felloe strips are then taken to a ıl machine which cuts the ends with proper relation to the holes so the wheel may be assembled. The last operation is facing which is a form of counter boring on the inside of the where the end of the spoke comes in contact with it.

he first stage in assembling the wheel is shown at A in the portion of the illustration. Here the spokes are driven into elloe and when the two halves of the wheel are available they ›laced in a special machine which clamps the spokes and the band tightly together. While the wheel is in this machine nmy hub is put in place and tightly clamped as shown at C. function of this is to keep the wheel together during the as- ly process. When the wheels have been clamped they are to an operator who cuts the joints in order to provide for hrinking of the steel rim. The clamped wheel is taken over special table where the rims are placed on them. The rims of are heated by a series of gas flames which play upon all por- of a steel rim or band until this has been expanded enough so heel can be readily inserted. The rim is dropped over one of nrimmed wheels as shown at C and placed under a heavy press

which forces the steel rim to its proper position on the wooden felloe. After the rim has been shrunk on, the false hub may be removed as the rim keeps the wheels together. The center is then bored out and a finishing cut taken on both sides of the spokes at the hub. The wheel is then carried to a drill press of the multiple spindle type which makes all of the holes for the brake drum or hub flanges. The final assembly process is to put the hub flanges in place and bolt them up.

A wooden wheel is not subject to damage or depreciation from use unless the car has skidded into a curb or hit some obstacle that will tend to knock the wheel out of true or break some of the spokes. As a rule, broken spokes can only be inserted by a wheelwright or one familiar with the manufacture of wheels. In cases where only one or two spokes are broken it is possible to insert new ones by unbolting the hub flanges and drilling out the broken end of the tenon pin that remains in the felloe. The new spokes, which may be made by hand in an emergency, are easily inserted in place of the damaged ones and the wheel assembly again clamped together between the hub flanges. In some cases, after a car has been used for a time, especially in dry sections of the country, considerable slack or looseness may exist between the hub flanges and spokes and also between the spokes themselves. No trouble will be experienced from this source if a car is washed frequently because the water will prevent the spokes from shrinking away from the hub flanges. Even if the looseness is noticeable, which is a fertile source of squeaking noises coming from the wheels while they are in service, in many cases the spokes may be swollen enough by soaking the wheel well with water to correct the trouble.

A simple method of overcoming this difficulty when the soaking treatment does not correct the fault is shown at Fig. 412. If the work is carefully done a badly racked wheel may be made capable of giving considerably more service. The hub is shown in the sketch with the flange removed to expose the mortised ends of the spokes to view. This may be easily accomplished by removing the nuts from the bolts and prying the hub flange away from the wheel. The lost motion between the spokes can be taken up by driving thin wedges of sheet steel into the open spaces though in some cases

the spokes are very loose hard wood wedges may be driven n making the wedges they should be shaped straight with a taper at the end to facilitate driving them in place. It is hat if made with a taper their full length that they will have lency to work out. Before driving the wedges in place they l be covered with a coating of glue and after all the wedges sary have been inserted the protruding edges can be cut off a chisel and the ends smoothed down flush with the spokes. e replacing the flange the center ; wheel should be red with a coat iming paint. Obviously, the wedges l be as wide as thickness of the s and only suffiy thick to take up pace existing be- the spokes. If a is not very loose, es 1, 2, 3, 4, 5, and driven into place, h in very loose s another set of es numbered 7, 8, 11 and 12 should ed to fill the reng space. It will

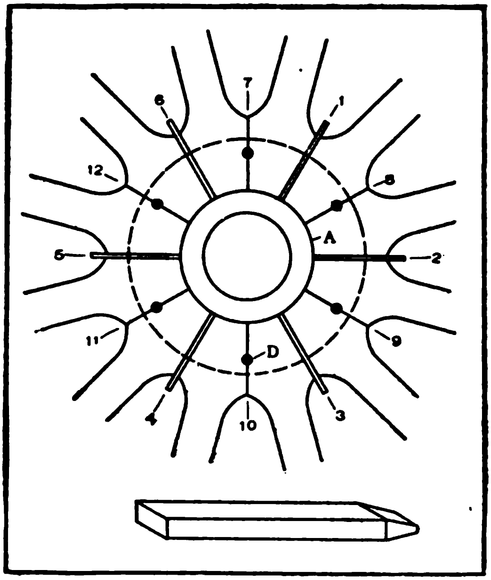


Fig. 412.—Method of Using Wedges to Take Up Looseness Between Spokes of Wooden Wheels.

parent that the bolt holes must be cleared out with a drill after edges have been driven in. The final operation is to replace ıb flange and bolt it tightly in position. It will be found ade to burr over the projecting ends of the bolt after the nuts rewed down tightly in order to prevent the nuts from backff. The wheels of some cars are held together by rivets inof bolts. As the heads of the rivets must be sheared off with a hisel to permit removal of the flange, new rivets must be in-

serted by a process of hot riveting when the wheel is agai sembled, taking care to use a rivet set in order to make a proj shaped head.

Houk Wire Wheel.—Many recent models of automobiles w found equipped with wire wheels of some form or other. Imp ments have been made in the method of lacing wire wheels so the forms used for automobiles are very strong. This is due method known as triple spoke lacing as this provides a combin that permits the wheel to support radial, torsional, side thrust shock stresses in a much superior manner to the old double s lacing formerly used on light automobiles and widely applie bicycles and motorcycles. Practically the only trouble that ca cur in a wire wheel is breakage of the spokes and as most wheels are of readily detachable form it is only necessary t move the defective members and replace them with new sp care being taken not to tighten the spoke nipple unduly and pull the rim out of true. The rims of the wire wheels used on mobiles are for the most part very strong and are not so like be pulled out of true as the lighter rims of bicycles or m cycles are.

If a large number of spokes are broken as might result fr collision or other accident it will be advisable after replacin spokes to true up the rim. This is done by revolving the w and holding a piece of chalk or crayon nearly against the whee to indicate the high points where the wheels run out. These p may be eliminated by screwing in on some of the spokes and lo ing on others until the wheel runs true. This requires som gree of skill but can be easily accomplished after a little pra The spokes are usually of high tensile strength steel wire hav button head at the lower end where they fasten to the hub a threaded upper end which screws into the nipple which draw spoke taut and which fits in a countersunk hole in the steel w rim.

A typical triple spoke wheel of Houk manufacture is show Fig. 413, A, while the method by which it is fastened to the m hub is clearly shown at Fig. 413, B. Most wire wheels are i so as to be easily detachable from a master hub which is no

ed from the wheel spindle or axle and which is supported by bearings or axle shafts. The wire wheel is built up with an liary pressed steel hub as a basis which is provided with a s of holes to fit over driving pins attached to the flange of the ter hub and which is formed on the inside with two tapered , the angle of the tapers being opposed to each other. One of male tapers forms part of the master hub which is shown at place on the front wheel spindle while the other male taper is

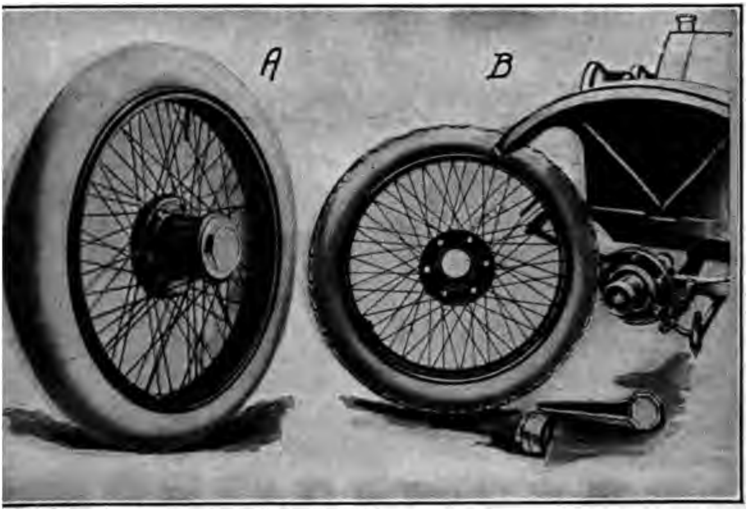


Fig. 413.—The Houk Detachable Wire Wheel.

the locking nut. When the lock nut is screwed onto the aded end of the master hub, which is sometimes termed the r or fixed hub, it forces the female taper on the inside of the ssed steel wheel hub against the male taper on the master hub. torsional force is applied to the wheel through substantial driv- pins which engage with registering holes in the hub flanges. These drive pins as well as the hub are treated with a special -proofing process and the pins are nickel plated, rendering cor- on or sticking of the parts difficult. If the wheels have been t on for a time and have not been disturbed it is likely that

some trouble may be experienced due to rusting of the pins the nickel plating will not protect these at all times. The r be easily cleaned off when the wheel is removed and a re of the trouble avoided by greasing the pins liberally be wheel is again replaced on the master hub. The constructio automatic locking nut which is a feature of the Houk clearly shown at Fig. 414. The hub at A is a rear hub att a semi-floating drive axle while that at B shows the conv

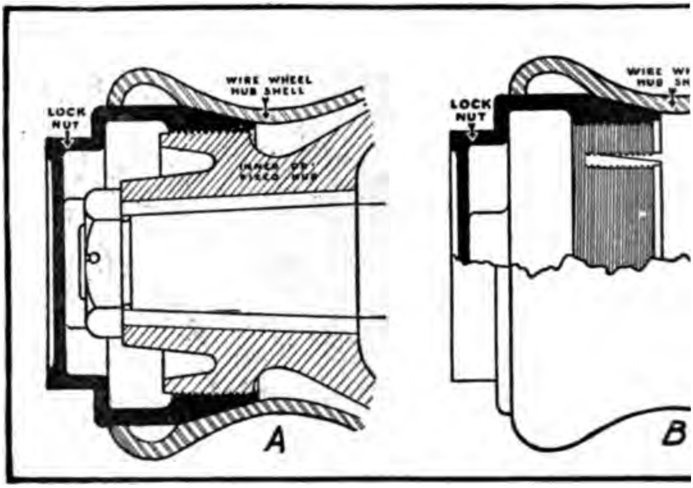


Fig. 414.—Showing the Automatic Locking Nut Employed or Houk Wire Wheel.

arrangement for a front wheel or the hub of a full float axle. These nuts are threaded for a loose running fit on th and have their conical end slotted into segments which slight compression when forced into the conical seat of shell. By virtue of the fact that the nuts are threaded lo the master hubs there is a difference in the circumferentia of the thread. If the nut is not drawn up tightly through the wheel supporting the weight of the car would bear t nut and as the wheel and hub turn when the car moves the nut must turn by a sort of epicyclic action which will

'eads to wedge together under the pressure of the load and after : manner of a cone clutch prevent slippage between the threads. is forces the nut to lag behind the angular travel of the hub rts and consequently to screw itself tighter on the threads when 'y are properly positioned on the car. On the right hand side of : car the hubs must be provided with left hand threads while on left hand side the hubs have right hand threads. When the ts are once in place there can be no creeping action, as they mp tightly down on the main thread owing to the slight comssion of the segments in the conical end of the hub.

Dunlop Wheel.—The Dunlop wheels which are shown at Fig. , have attained great popularity in Europe and are now being l to some extent in this country. This wheel is very quick in ration and is locked in place positively as soon as installed. inner hubs are made of bar stock for the front wheels and drop gings for the rear, no castings being employed. As is true of wire wheels, the hub is composed of two pieces, one, which is a ter hub intended to remain in permanent assembly with the porting bearings while the outer or removable hub to which the tes are fastened is readily detachable. The outer hub is pre:ed from turning on the inner one by serrations or teeth which located near the conical surfaces at the inner end of the hub. se teeth are external on the inner hub and internal on the outer are formed to fit between each other. The engaging portions he teeth are rounded off to enable them to slip easily in mesh. econd conical surface at the outer end of the outside hub rests the hub cap, which is locked in place in the outer portion so it cannot drop out when that part is removed from the inner , but at the same time it is free to turn in order to screw on the r portion. As the locking of the hub cap from unscrewing rmines the safety of the wheel from coming off this is an adtageous point.

A cup shaped member is placed inside of the outer end of the inhub, this is kept from turning in the hub by serrations similar hose between the two portions of the hub, but is free to slide in out within certain limits and is normally pressed outward by il spring. At the outer end are more serrations, formed to fit

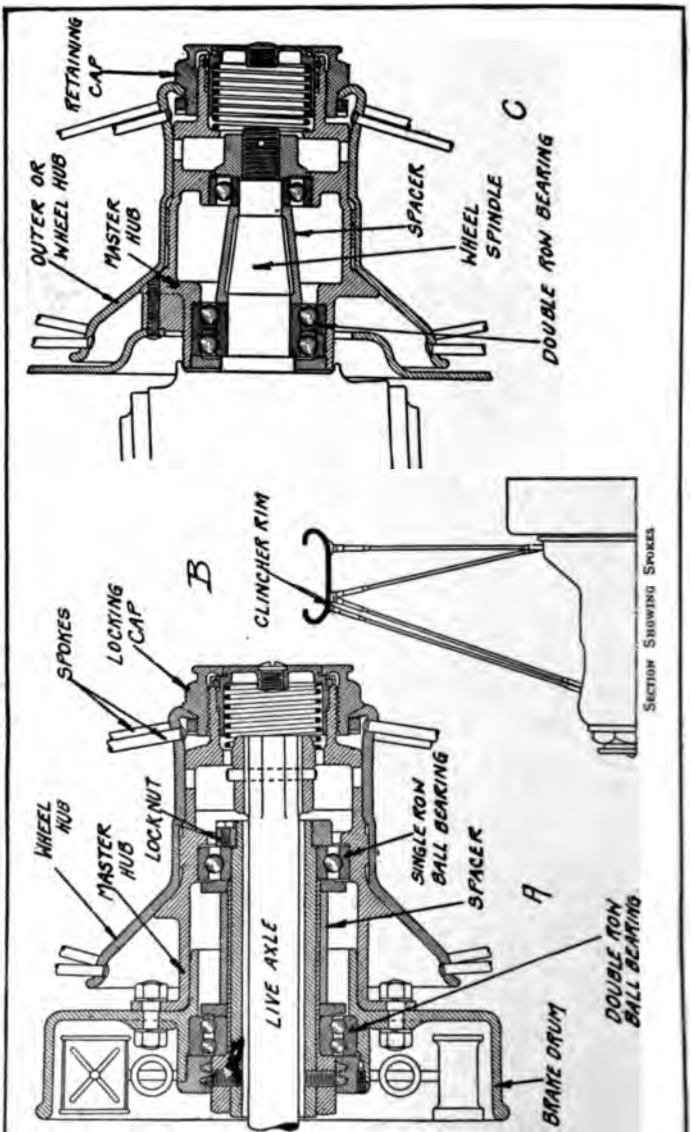


Fig. 415.—Sectional View Showing Construction of the Dunlop Quick Detachable Wire Wheel.

corresponding parts in the hub cap. This lock is held out of gagement while the wheel is being attached or detached by an tachment to the wrench. Immediately upon the removal of the rench it is pressed in contact with the hub cap and if not al- ady in position to engage it will come in to the locking position the hub cap turns one-sixth of a turn. A special wrench or anner is needed for handling the Dunlop wheels. This is of dinary box wrench form except that it has pawls or latches which gage in a groove at the outer end of the hub caps to hold the rench in place and a bridge across the middle which carries a uick acting screw to depress the locking device on the inner hub. n removing the wheel the wrench is snapped in place on the hub ap and the central screw turned down to release the locking piece, hich permits the hub cap to be turned off easily. In attaching, is screw should be turned down also in order to prevent the lock rom taking hold before the cap is fully screwed home. After the ocking cap is forced in place the lock should be released before re- noving the wrench and the nut turned till the lock engages so as o prevent even the slight looseness that would result if the lock lipped back into the next notch. The lacing of the spokes is in hree planes like the spokes of the Rudge-Whitworth wheels which re made under the same patent. The sectional view through he end of a rear axle fitted with Dunlop wire wheels is shown at Fig. 415, A. As will be evident, the master or inner hub is carried by a combination double and single row bearing mounting, the louble row form being clamped to take the end thrust on the wheel. The axle is a floating type, the bearings being mounted on the tubular housing of the live or driving axle. A similar con- struction is used for the front wheel which is shown at Fig. 415, C. The method of lacing is outlined at B.

Rudge-Whitworth Wire Wheel.—The construction of the Rudge-Whitworth wire wheel, which is a very popular form, is shown at Fig. 416, A, while an enlarged sectional view of the wheel hub construction is shown at B. These are triple spoke wheels con- isting of a removable outer hub and a master hub mounted on ball bearings. In the illustration the permanent hub A revolves upon he *plainly indicated* ball bearings while B is the wheel hub. Th

driving teeth or serrations are indicated at C. These are about ten in number to each circumferential inch. The wh D is circular in form and has notches cut from its circum to engage with projections from a special spanner when it t necessary to revolve it.

This nut has a locking ring L on its inner end and an groove N between the nut and locking ring. When the nu

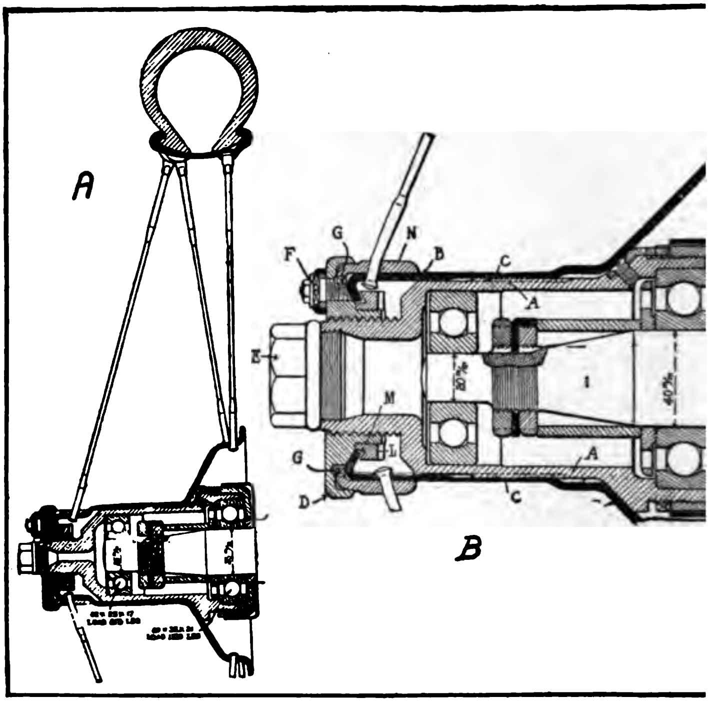


Fig. 416.—Sectional View, Showing Construction of Rudge-Wh Wire Wheel.

volved to the right it drives the wheel up into the perman while revolution to the left withdraws it. A large screw pl provided for lubricating the bearings of the wheel. The device of the Rudge-Whitworth is said to be "meddle pro

ι that there is a steel cap M fixed on the outer end of ub and that this has a female ratchet G cut in the ends. t has to engage a pawl mounted on a small bolt well the wheel nut. The pawl is kept in engagement by a ıese parts form the automatic part of the lock. A employed to move the wheel which has an opening to eel nut but it cannot be placed thereon until a small forms part of a lock is swung around so the pawl ıgages in a depression, in which case the spanner can ıt in position. The nut may be revolved freely until s detached. In tightening the wheel into position the st be turned until the wheel is completely in place and vord "safe" is not exposed in the opening, a few strokes et on the end of the wrench will insure absolutely cor-. The direction of spanner rotation should not be re- n the wheel is being attached as this disengages the ls.

re Forms.—Practically all commercial vehicles of over pacity are equipped with solid rubber tires. A number vehicles, even some forms designed for pleasure pur- tted with cushion tires. A number of representative ıown at Fig. 417. Solid tires may be of the permanent- d or quick detachable types depending upon the pref- ıe truck user. The driving wheels of motor trucks are tted with dual tires in order to secure greater carrying thout using excessively wide and expensive tread mem- basis of most solid tires is a ring of steel which has pro- ions to which a base of hard rubber is vulcanized. This l rubber makes for secure attachment of the tire which of an especially tough rubber compound. In the per- ssembled forms of tires, the metal base member is ma- ıat it can only be installed on the wheel rim by pres- a hydraulic press. This means that tires can only be stations where the press facilities are available. The e shown at B has many advocates because it can be lled without expensive tools. In this form the metal r integral with the tire has beveled edges which rest on

correspondingly beveled flange members drawn tightly in bolts which pass through the wheel felloe and which hol taining flanges firmly in place. This method of construc popular one when twin tires are employed as shown at B

The cushion tires are usually designed to provide mo ency than is available with the solid tires. The usual m

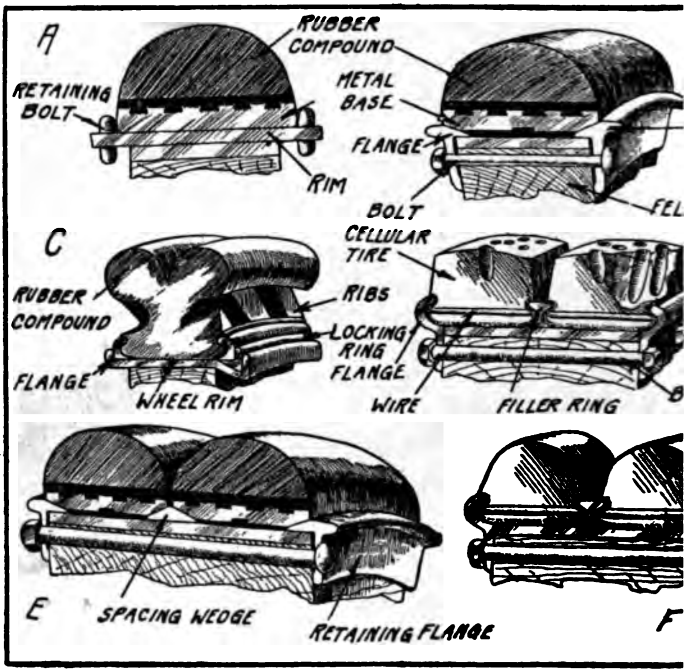


Fig. 417.—Defining Construction of Solid and Cushion Tires and of Retention to the Wheel Rim.

obtaining this elasticity is to form the tread in some sh will deflect or distort appreciably under load. The cus shown at C has the tread portion supported by ribs wl give to some extent when the tire passes over a stone or ot obstruction that the solid tire will ride over. In the cus shown at D, resiliency is obtained by making a large n

a the tire. Repairs to solid tires can best be made at the ' where they are produced and these are seldom necessary the tire has been cut by accident. As a rule when a solid ars down the only practical remedy is to replace it, as it is ıceptible to retarding as the pneumatic tires are.

lern Tires Are Well Made.—There is an impression obtain- :h motorists, and even with many engaged in the industry, 'e expense is an element in automobile maintenance depend- re upon good fortune than any care of the tire manufacturers lucing good tires, or in the motorists using reasonable judg- nd care in driving, and taking precautions that the shoes ceive the same attention given other components in the vehi- he average person, whether tradesman or layman, seldom rs the enormous stresses to which tires are subjected on even itest of runabouts and motorcycles, and as a general rule. hoes are fitted to the rims, they are forgotten until abuse less driving causes sudden end to their usefulness. Natural ıay make replacement necessary and while the American ıcturers of tires are producing types that are enduring and al, with even the best of care the tire must eventually wear me standard tires may be better than others, but all are good ll give satisfactory service if properly used. The fact that cient motor car of to-day would not be possible or practical ; the resilient support and increased tractive effort given by ıumatic tire is not often considered, and tires are regarded cessary evil, though they are really one of the most essen- l hardest worked components of the motor vehicle.

s not intended to go into the details of tire manufacture, ompare one form with another, as the actual methods of ction are of little concern to automobilists and those in the ınd instead of a review of the technics of tire manufacture, ter desires to give some practical information relative to cesses of repairing tires found to be satisfactory in appli- based on experience gained in both factory and shop. Such s seldom published and many motorists and repairmen as- ıat automobile tire repairing is a mysterious occupation that ıd their comprehension. Not only among automobilists, but

throughout the greater portion of the trade as well there is no clear conception of the processes or the careful manipul necessary to repair tires successfully.

Construction of Tires.—While much advice has been given tive to the care of tires it will be well to speak of some cau deterioration, and for the better knowledge of the uninfo reader the conventional methods of tire making and the qu of the materials used are outlined. The principal materi vehicle tires are rubber compounds and textile fabrics, and factory has its own peculiar processes of combining these to the finished tire. Practically all tire manufacturers procu fabric from firms making a specialty of textile products, bu erally any concern manufacturing rubber goods prefers to use special compounds which experience has shown are best ad for the appliances they manufacture. The basis of all ti undeniably fabric and crude rubber, both of which are of table derivation, the best fabric being of Sea Island cotton, the caoutchouc, or India rubber, is the product of a great v of trees, vines and shrubs, most of which grow in the torrid

The substance which gives the modern tire its strength fabric forming a basis for attachment of the rubber, and many materials have been tried, among them silk, wool and cotton alone combines most of the required qualities. Befo corporation in tires this fabric is thoroughly dried and in nated with rubber. Nearly all tires are formed or built on and are composed of layers of fabric and rubber.

At Fig. 422, A, a sectional view of a "bolted-on tire" is which will serve to illustrate the manner in which a tire is of layers of materials. The outer layer is specially tough known as the tread, of such composition it is strong and sp adapted to resist abrasion, firmly attached to two layers of known as breaker strips, which rest on another layer of softe more resilient rubber than that of which the tread is com termed the cushion or padding. The main body of the tire co of layers of the frictioned or rubber impregnated fabric, the ber of plies varying with the size of the shoe. In the base tire are incorporated hard rubber and fabric fillers to mal

cture of maximum strength. These successive layers are then into intimate relation by vulcanization.

Jause of Deterioration.—It is evident the pneumatic tire is a bination of materials that in themselves are not specially en- ng, and it is not reasonable for one to expect lengthy service ı a tire. In considering the causes of deterioration we will me the tire is a standard product of a reputable maker whose esses of manufacture eliminate defects which might result from material or workmanship. If the shoe is poorly made it will and the layers of fabric and rubber will separate, or the side s will crack; if the wall is too thin or of insufficient strength it blow out, tear or cut, and at the other hand if there be too h fabric used and the walls are too thick, the flexibility is re- d, the difficulty of bending under load is increased, the side s are forced to assume sharp angles and the fabrics will be ured. If the tire be not properly vulcanized, the layers will n from each other and if the rubber compound is not right ioration will be rapid. If the tire is cured too long its life be short, because the process has changed the chemical com- ion and physical characteristics of the materials employed. It be evident that if one regards only the product of experienced rs that faults due to poor construction and material cannot gically considered.

erhaps the most common cause of tire deterioration is abuse ıe user, and on the other hand there are unavoidable causes, as punctures or hard service. Overloading and insufficient ion are the two most common causes of poor tire service, and seldom that the motorist observes the most simple requirements will insure satisfactory tire life. Each size of tire is designed s makers to carry a certain weight which should never be ex- d, and if the weight schedule is followed in designing or equip- a car, good results may always be expected from tires, pro- l they are not otherwise abused. If the shoes are overloaded nable service cannot be expected, as no tire, no matter how made, can continually resist the internal pressure necessary ep it inflated enough to support the load when of insufficient ity.

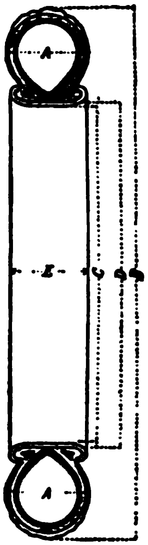
The most important advice given the purchaser of tires keep them properly inflated, and its value cannot be overestim More tires become useless from use with too little air pressure all other causes combined, and while most drivers assume they sufficient air in the tires they use it is a fact they habituall tires that are not properly filled. The tire should contai enough so that it shows but little change in form when the standing on a hard surface under full load, and even under conditions it will be found that the tire is compressed conside when the car is in action.

The Cord Tire.—A method of tire construction that is b ing popular because of its easy riding qualities is a difficult to repair and is shown at Fig. 420. Instead of layers of fabri main portion of the carcass, or casing, is composed of cores are passed around small wires at the base of the tire and whic wound very tightly in order to secure intimate contact betwee various layers of cord. Sheet rubber is placed between the layers and fabric breaker strips are placed between the trea the cord body in the usual manner. When the tire is vulca the spaces between the layers of cord become filled with the ber, and the whole mass is firmly bound together. The wire ject into the bead portion of the tire and are vulcanized firn place. Owing to the construction a cord tire cannot be as repaired as the fabric type because it requires a very expert k edge of cord tire construction to replace injured portions du blowout. As we shall see, the fabric tire may be restored t ciency by cutting out layers of the defective fabric and vulca new layers in their place. This is not a difficult operation, wh replacing the defective cords calls for a degree of skill not u possessed by the tire repairman.

Rims for Pneumatic Tires.—An expert has stated that are at least forty different types of tire retaining rims that received general application and that these require at least teen different sections of wood wheel felloes. Besides the va well known and popular rims a number have been designed are more or less complicated and which are said to possess va desirable features by their manufacturers. There are six

CLINCHER TIRE AND RIM DIMENSIONS

Regular Clincher Rim



A Inches	B Inches	C Inches	D Inches	E Inches
2 1/2	26	18 3/4	19	1 3/8
3	26	19 3/4	20	1 3/8
2 1/2 and 3	28	21 3/4	22	1 3/8
2 1/2 and 3	30	23 3/4	24	1 3/8
3	32	25 3/4	26	1 3/8
3	34	27 3/4	28	1 3/8
3	36	29 3/4	30	1 3/8
3 1/2	28	20 11/16	21	1 3/8
3 1/2	30	22 11/16	23	1 1/2
3 1/2	32	24 11/16	25	1 1/2
3 1/2	34	26 11/16	27	1 1/2
3 1/2	36	28 11/16	29	1 1/2
4	30	21 11/16	22	2
4	32	23 11/16	24	2
4	34	25 11/16	26	2
4	36	27 11/16	28	2
4 1/2	32	22 11/16	23	2 1/4
4 1/2	34	24 11/16	25	2 1/4
4 1/2	36	26 11/16	27	2 1/4

Fig. 418.—Standard Clincher Tire and Rim Dimensions.

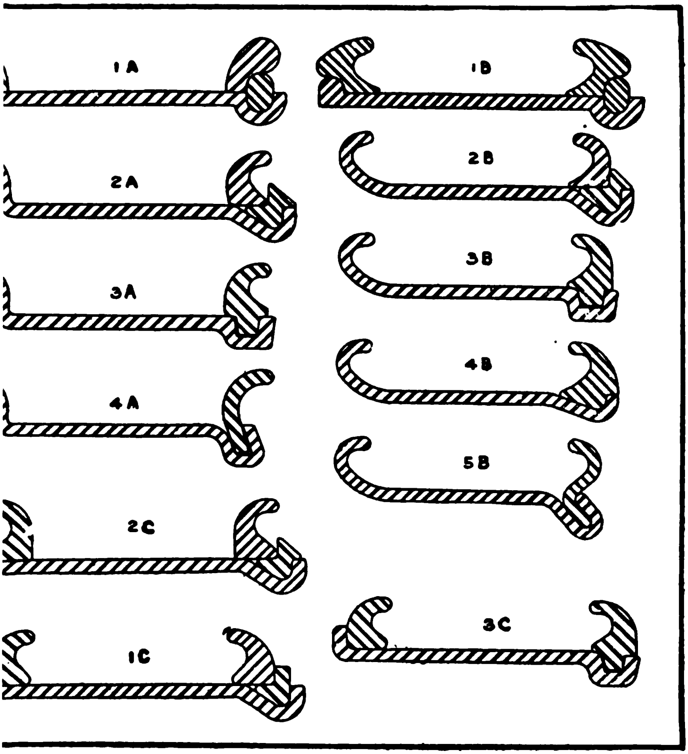
ative groups into which the various rims manufactured to-day be classified. These are: 1. One piece clincher. 2. Quick de-able clincher. 3. Quick detachable straight side. 4. Quick de-able universal. 5. Demountable. 6. Demountable detachable. distinction between the two last classes is that there are a large ber of demountable rims which have to be taken off of the el before the tire can be removed. There are others that not have the demountable feature but from which the tire can be oved while the rim remains on the wheel.

The one piece clincher rim with its principal dimensio various tire sizes is shown at Fig. 418. This rim is made ir piece and not cut in any direction. It is adapted only for us tires having soft extensible beads which can be pried or lifte the edges of the rim. There is only one type of clincher ri the market but at the present time its use is confined to smal medium weight cars as too much effort is needed to install size tires on rims of this form. There are many types of qui tachable clincher rims which have been designed to make pc quick application of clincher tires which are well thought account of the holding power of the tire beads. These rin invariably composed of two or three parts, consisting first rim base with an integral inside clinch, or separate inside e clincher ring and a separate outside clincher ring which is so that it may open with some fastening device for holdin ends in place or it may be made endless with an open lock r hold it in position.

Examples of the most popular form of quick detachable cl rim are shown at Fig. 419. The form shown at 1-B is a type has a base, two endless clincher side rings and an open en ring which may be snapped out of its seat, and permit t moval of the outside clincher ring and then the tire if it co no air pressure. The rim shown at 2-B has the inside clin tegral with the rim base, the outside clincher ring and th ring being similar in action to those of 1-B though differ design. The rims shown at 3-B and 4-B are similar to ri except that the outside clincher ring is open ended having chanical lock for the ends of the ring. Rim 5-B has an ope outside clincher ring with an angle of the retaining groove rim base of such form that the inflation of the tire causes it t home more firmly so that no locking device is necessary.

Forms of quick detachable straight side rims are shown i same illustration, these being very similar in construction to previously described except that the retaining rings are made straight side tires instead of clincher tires. The straight sid which was originated by Dunlop, has a bead devoid of any c ing arrangement though the bead is not extensible as it has

iano wire rings firmly vulcanized in the base portion to ıuch extension. The retaining means in the rim shown at A inclusive are practically the same as those outlined from -B inclusive. A number of combination rims has been



—Sectional Views, Showing Construction of Quick Detachable Rims that Have Received Practical Application.

vhich can be adapted to take either straight side or quick le clincher by merely reversing the retaining rings which ction adapted for retaining either the clincher bead or the side form. These are shown at Figs. 1-C to 3-C, inclusive. ıples of quick detachable demountable rims are shown at , A. As will be observed these are rims of the simpler

form having tapering flanges on the base by which they
to the wheel felloe by suitable wedge rings or clamp nu
mountable rims are shown at B. These are adapted to re
standard clincher rings as shown in the upper portion o
lustration or the one piece straight side Dunlop rim as s
the lower part of the illustration. As will be apparent
are held in place by a series of wedges which are force
space between the tire carrying rim and that attached to t

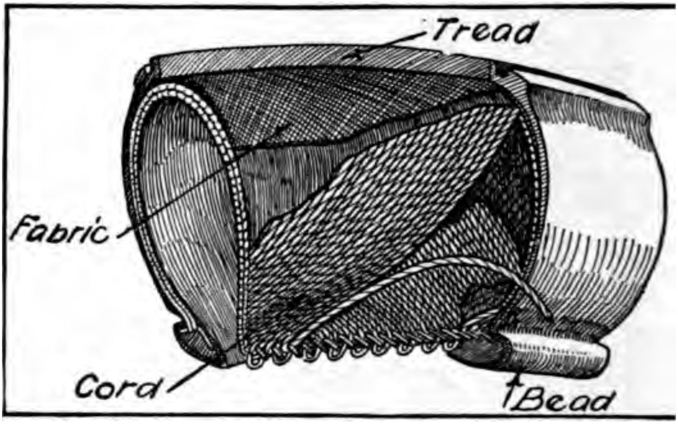
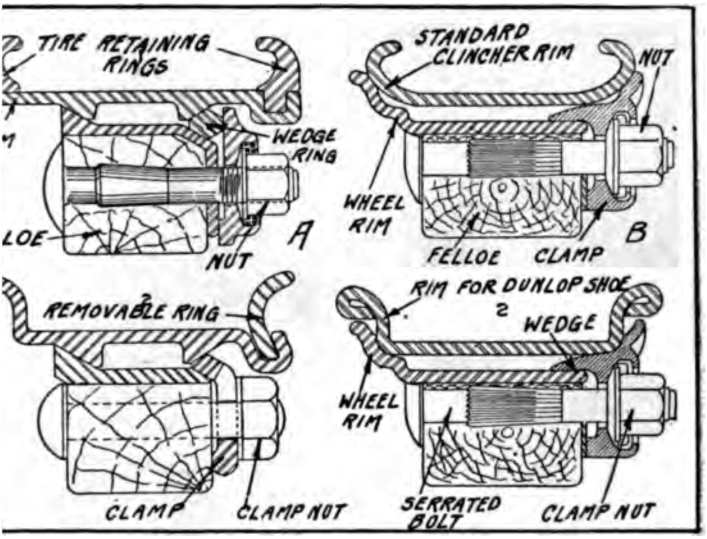


Fig. 420.—Sectional View, Showing Arrangement of Cords that the Fabric Carcass in the Palmer System Cord Tire Constru

felloe. A form of tire retaining rim that was formerly v
ular is shown at Fig. 422, A. This is known as the Fisk B
type and could only be used in connection with a tire
base of the form shown in the illustration. The tire was
held to the steel rim by means of retaining rings wh
clamped firmly in place by bolts carrying specially formed
designed to clamp over the edge of the retaining ring a
that of the rim. When it was desired to remove the r
special tools shown at Fig. 422, B, were needed. The speci
ing member was used to squeeze the rings closely together
mit screwing up the retention nuts with the special socke
provided for the purpose. When the retaining bolts had

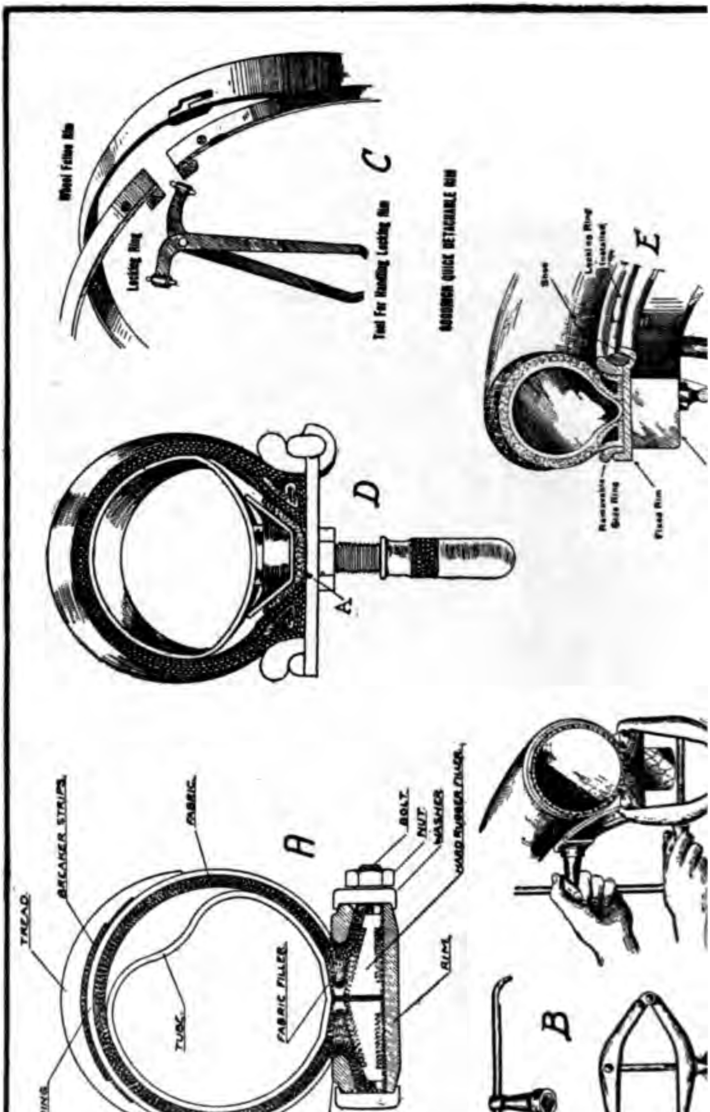
l all the way around the tire the rings could be withdrawn ; tire easily pulled off of the flat rim. When the tires were d the clamping member came in handy to squeeze the rings e portions of the tire base closely enough together so the uld be caught on the end of the bolts.

Goodrich quick detachable rim and the special tool needed manipulation are shown at C. The feature is in the shape of



21.—Sectional Views, Showing Construction of Quick Detachable Demountable Rims.

xing slot in the rim attached to the wheel felloe. The open :king rim carries tongues which fit into the slot and which sprung into place to securely lock the rim. The tool shown ided to facilitate bringing the end of the locking rings to- in order to spring the tongues into the locking grooves. The the ends of the levers fit suitable pin holes in the locking r. When it is desired to remove the ring one of the tongues l out of its locking groove and then pulled away from the all points. After the ring has been partially detached it is


TREAD
BREAKER STRIPS
FABRIC
PADDING
TUBE
FABRIC FILLER
RING
RIM
BOLT
NUT
WASHER
HARD RUBBER FILLER
A
B
C
D
E
Wheel Felloe Rim
Locking Ring
Tool For Handling Locking Rim
Shoe
Removable Side Ring
Fixed Rim

difficult to remove the remaining tongue from the wheel felloe When replacing this locking ring, the first step is to catch tongue on one end of the ring under the wheel felloe rim by rting it in the notch nearest the edges of the rim. The ring is forced in place all around and finally locked by bringing the aining tongue in the groove nearest the center of the wheel and springing that in place over the projecting portion near the e of the rim. The method of installing a straight side tire when m of the form shown at Fig. 419, 1-A, is used is clearly shown at . 422, D and E. The section at D shows the method of install- the spreader member at the base of the valve properly while general application of the locking ring may be clearly ascer- ed at E.

Tools for Tire Repairs.—It is necessary in all cars using pneu- ic tires to carry a certain amount of equipment for handling repairing these on the road. A typical outfit is shown at Fig. this supplementing two spare outer casings, and two or more inner tubes for replacement purposes. Included in the re- outfit are a blowout sleeve, a number of patches, and an acid- vulcanizing outfit for applying them. Tire irons are provided emove the casing from the rim; the jack is used to raise the l of the vehicle on which the defective tire is installed from the nd and make it possible to remove the tire completely from wheel. The air pump is needed to inflate the repaired tube or new member inserted to take its place. Talcum powder is pro- d to sprinkle between the casing and the tube to prevent chaf- or heating, while the spare valves and valve tool will be found ul in event of damage to that important component of the in- tube. As it is desirable to inflate the tires to a certain definite sure, a small gauge which will show the amount of compression ie tire is useful.

The outfit shown may be supplemented by other forms of vul- zing sets and by special tire irons to make for easier removal he outer casing. Tire irons vary in design, and most makers ires provide levers for manipulating the casings, which differ ome extent. A set of tire irons such as would be needed with incher tire equipment could be selected from the forms shown

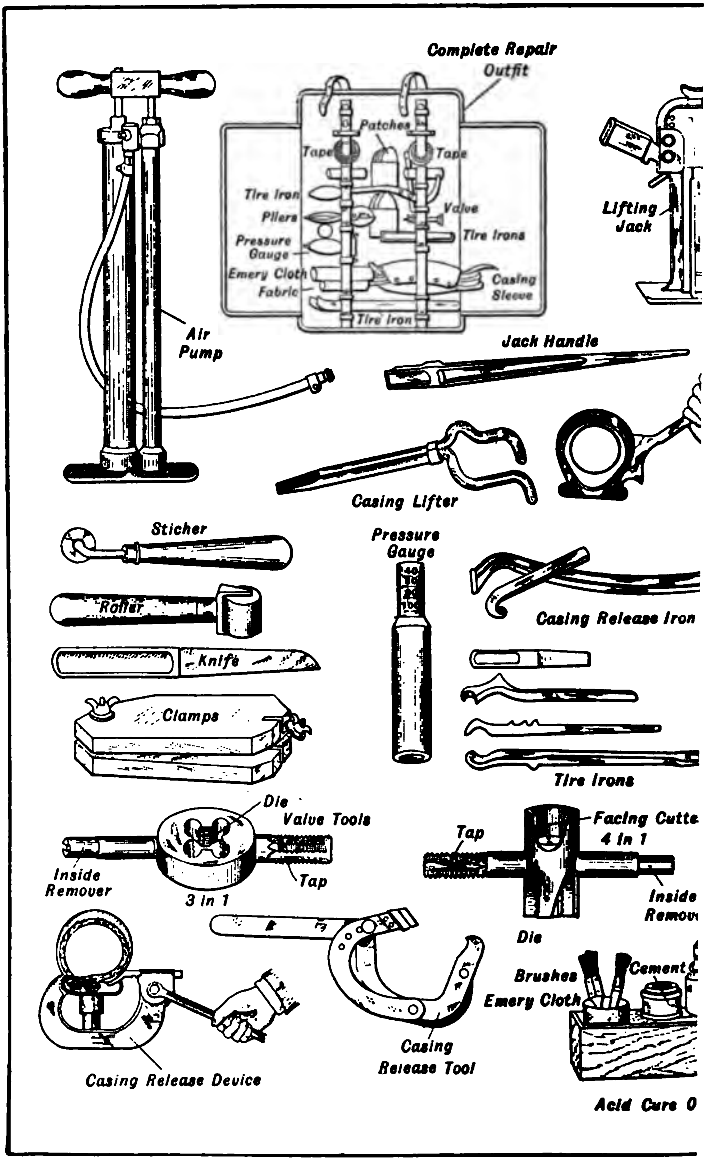


Fig. 423.—Tools and Supplies for Pneumatic Tire Restorati

t Fig. 423. That shown near the gauge is utilized to loosen the lincher bead from under the rim should it become rusted in place. After the shoe has been loosened from the rim flange, levers of the orm shown below it would be inserted under the bead in order o lift it over the rim. Two or more of these levers are necessary, he long ones being more easily operated than the short ones. The ength of the lever provided will depend entirely upon the size of he tire to be removed. Motorists, as a rule, should carry one of he releasing levers shown, two of the short members depicted and ne longer lever. The latter may be a combination form which an be used as a jack handle as well as a tire iron, and then it is ot necessary to carry a jack handle in the equipment. The flat- ened ends are generally employed for prying the bead from the lincher rim, and when this has been done and sufficient space xists between the bead and the rim to insert the curved end of the arge levers, considerable leverage is obtained and the bead may be ifted over the clincher rim without undue exertion. The object f rounding the corners, and of making the working portions as road as possible is to reduce the liability of pinching the inner ube, which would be present if the irons had sharp edges.

The tire repair material is sometimes carried in a special case, s shown at top of Fig. 423, this consisting of all parts necessary o make temporary repairs to be considered in proper sequence. This outfit is sometimes supplemented by other special tools. A nife is needed to cut the rubber, trim patches, etc. The stitcher nd roller are useful in rolling the patch after it has been cemented o the tire to insure adhesion of the patch firmly against the dam- ged portion of the tube while the cement is drying. Some motor- sts carry a small flame heated vulcanizer in order to effect more ermanent repairs than would be possible with the simple patch- ng processes in which only the adhesive powers of dry cement are vailable.

Portable Air Compressor.—Some Locomobile cars are equipped ith a single cylinder air compressor, having a bore of 2½ inches, nd a stroke of 2½ inches, which may be considered typical of such evices which are often included on recent models of leading cars. t is mounted on an extension of the front end of the transmissi-

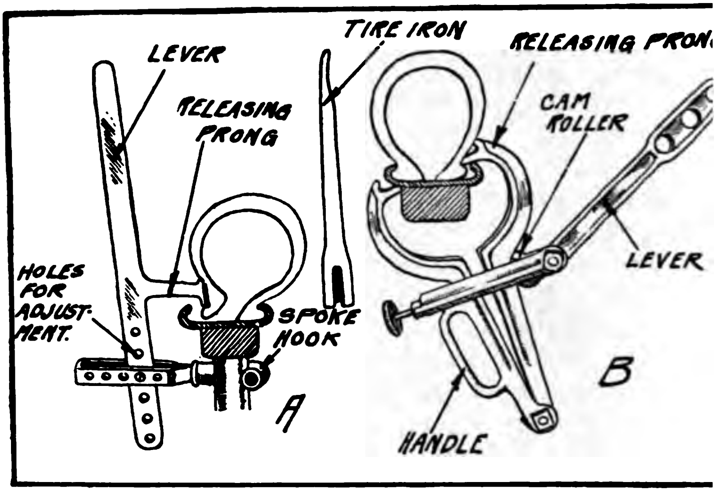


Fig. 424.—Tools for Releasing Clincher Tires When Beads are Ru
the Rim Channels.

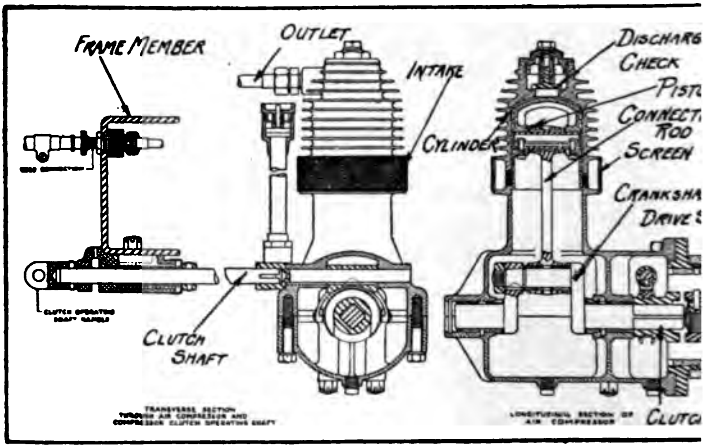


Fig. 425.—View Showing Construction of Small Air Compresso
on Locomobile Cars for Tire Inflation.

ntershaft, and driven by means of jaw clutches, which can be ›wn in and out of engagement by a T handle located on the side of the car, and reached by opening a door in the running-rd side shield. By drawing handle outward about $\frac{3}{16}$ of an ı, advancing one notch to the left in a serrated segment and re-ing, jaw clutches are interlocked and pump is ready for use. is drawn into the cylinder through holes drilled around same ›w radiating fins. Foreign matter is excluded by means of a .ovable screen. On the upper stroke of the piston the air is :ed out of the cylinder by unseating a flat valve into a small k placed at the right of the air compressor, and mounted in ıt of the transmission carrying channel. The purpose of this k is to overcome the pulsation of the pump only and not to act ı reservoir.

By means of a two-way fitting air is drawn out of the tank ›ugh a delivery tube leading to a fitting which projects through left side member of the frame adjacent to the T handle men-ıed above. One end of the tire hose is screwed on to this fitting :n tires are to be inflated. The location of the two-way fitting the tank is such that any sediment or oil falls to the bottom of tank, and is not drawn out through the delivery tube. With motor running at normal speed the air compressor will inflate 7 x 5 inch tire to 90 pounds pressure in about two minutes. :ry 2000 miles, or oftener if the compressor has been used fre-ntly, the oil in the crank case should be replaced. The crank : is drained by removing a plug located on the bottom. To fill, ıove both the large and small plugs on the left hand side, and :r oil through the larger hole until it overflows through the ıll hole. In case the oil which was removed seems especially :y, fill the crank case with kerosene and drain before putting in r oil. This compressor is clearly shown in Fig. 425.

Tire Manipulation Hints.—In removing or replacing outer cas-s, considerable care must be exercised not to injure the shoe or ch the inner tube. The first step is to jack up the wheel from .ch the defective tire is to be removed, thus relieving the wheel :he car weight. The valve inside is then unscrewed in order to ›w any air that may remain in the tube to escape, and then the

lock nuts on the valve stem are removed so that this membe be lifted to release the clincher beads from the rim channel the tire is stiff or has not been removed for some time, a s iron is utilized to loosen the edges and the beads are pushed of the clincher rim.

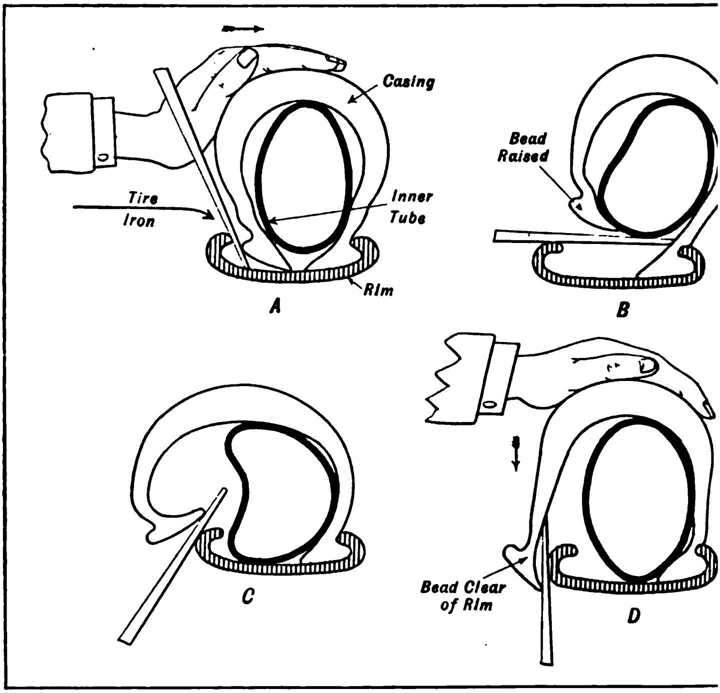


Fig. 426.—Defining Manipulation of Clincher Tires.

When the casing has been loosened on one side, a flat t shown at Fig. 426, is inserted under the loose bead to act as or lever to work the edge of the casing gradually over th Very long levers are necessary to handle new stiff tires, ar used casings are particularly hard to move. The shorter iron be employed on shoes which have been used for some tim which are more pliable than the new ones. Two of the lev

generally used together, one being kept under the loosened edge of the bead, while the other is used to force the bead over the edge of the rim. When the outside edge of the bead has been forced over the rim at all points the inner tube is lifted from the rim and is pulled out of the shoe. The start at removing is made at the point diametrically opposite the valve stem. When this portion has been pulled clear of the rim and out of the casing it is not difficult to pull the rest of the tube out and finally lift the valve stem out of the hole through which it passes in the wheel felloe, and take the inner tube entirely off the wheel. If the casing demands attention, or if a new shoe is to be used, the inside bead is worked over the channel of the clincher rim in just the same manner as was done with the outside bead, and after a start has been made and a portion of the inside bead forced over the rim there will be no difficulty in slipping the entire shoe from the wheel.

Applying a tire is just the reverse to removing one. The first operation is to place the inner bead of the tire in place in the center of the rim by forcing it over the outside flange. This is done gradually, and in order to force the remaining portion of the shoe it may be necessary to use long levers when the greater part of the casing has been applied. The next step is to work the shoe gradually toward the inner channel of the rim, then to insert the air tube. The inner tube is replaced after it has been partially inflated by putting the valve stem in first and then inserting the rest of the tube, being careful not to pinch it under the beads.

After the inner tube has been put in place, the outer bead of the tire is worked over the edge of the rim channel. Care must be exercised to insure that the inner tube will not be pinched by the sharp edges of the tire levers. The object of partially inflating the inner tube is to distend it so there may be no loose or flabby portions that are liable to catch under the tire bead when this is being forced in place over the wheel rim. The conventional method of inflating tires by using a foot pump does not always insure that they will receive adequate inflation, and when a pump is employed it is imperative that some form of gauge be provided that will register the amount of pressure inside the tire in order that it will reach the figure recommended by the tire makers. Different me-

ods of tire inflation have been devised which eliminate the necessity of using manually operated pumps. Obviously a simple expedient would be to provide a small power-driven pump that could be actuated by any convenient mechanical connection with the engine or a spark plug pump. Another method is to use an air bottle, which is a steel container in which air is stored under great pressure. The air is compressed to such a point that a tank less than two feet long and six inches in diameter will furnish sufficient air to inflate seven or eight large tires or twelve small ones. The tank may be exchanged at small cost when exhausted for new containers holding a fresh supply of air. In some tanks, gases of various kinds under high pressure are used and the motorist may obtain these on the same basis as air bottles are supplied.

All devices of this character are fitted with gauges to indicate the amount of pressure in the tire, and to prevent overinflation. If a tire is not properly inflated the shoe will be liable to various kinds of road damage and will be easily punctured, while if the pressure is too high the shoe is liable to "blow-out" at any weak point in the structure. A tire-pressure gauge is a very necessary article of equipment in any car and its proper use when blowing up tires will insure the best possible results if the schedule recommended by the tire manufacturers is adhered to. Three inch tires should be inflated to 60 pounds, and three and one-half inch to 70 pounds pressure. The rule is approximately 20 pounds for every inch of tire width.

Small Vulcanizers.—A number of portable vulcanizers designed for the use of the motorist so that tires may be repaired without removing the casing from the wheels if surface cuts are to be vulcanized is outlined at Fig. 427. These operate on three different principles, some depending on the heating effect of coils conveying an electric current, others upon steam produced by a small burner acting upon the water contained in the casting while the simplest form utilizes dry heat produced by burning gasoline in the vulcanizer. The form at A obtains its heating property from steam and is shown clamped in place to seal a cut in the casing. The form at B is heated by electric current and is also shown clamped to an outer casing. The form at C derives its heat from the flame

[redacted]

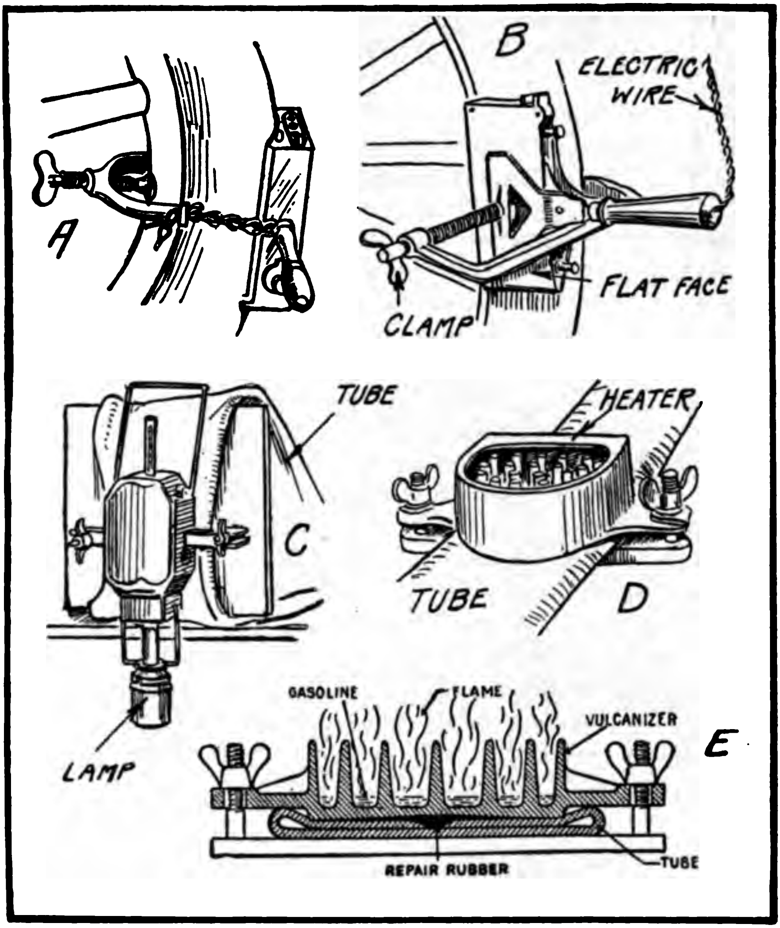


Fig. 427.—Views Showing Small Portable Vulcanizers Suitable for Road or Shop Repairs.

of a small lamp burning alcohol or gasoline which heats water contained in the body of the device. This has two faces, one flat for use in vulcanizing patches and inner tubes as shown, while the other is curved to permit it to make repairs on outer casings. The form at D *is used only* for inner tube work and the method of

action may be readily understood by referring to the cross section at E. The heating portion consists of a simple casting having a number of projecting fingers which are heated by the flame of burning gasoline. A definite amount of fuel is poured into the heater and ignited and after this has burnt itself out enough heat will have been imparted to the casting to produce satisfactory vulcanization of the repair material placed in the defective portion of the inner tube. These small vulcanizers are intended primarily for the use of the motorist in making minor repairs and are not practical tools for the tire repair shop, though they may be used to advantage in small garages where no attempt is made to carry on tire repair work on a large scale. Under these conditions they will prove practical in coping with the various emergency repairs such a garage may be called upon to perform.

Shop Vulcanizing Equipment.—There is considerable difference between the vulcanizing equipment intended for the use of the average motorist or small repair shop and that intended for commercial work. Whereas the small vulcanizers are usually intended for curing but one tube patch or casing patch at a time the large ones have provision for treating a number of tubes and casings at one heat simultaneously. Practically all of the commercial vulcanizers operate by steam. This is generated in a small boiler and is led to the various molds and plates for curing the inner tubes. A steam gauge is provided as the temperature of the steam may be readily determined by its pressure and in some cases a safety or blow off valve is provided to prevent the generation of too much steam.

A typical vulcanizing outfit having a capacity for curing three inner tubes and two casing sections is shown at Fig. 428. The tubes are cured on a flat plate which is at the top of the boiler while the steam for curing the casings is led to the hollow mold carried by the table. A gas burner is provided to produce the heat necessary for turning the water contained into the boiler to steam. Valves are placed in the various steam lines in order that the flow may be controlled. A group of vulcanizers of various patterns is shown at Fig. 429. The feature of the Shaler automatic plant shown at A is a machined surface 4 x 30 inches which will re-

anize six tubes as easily as one. It can be heated independent of the casing attachment or used simultaneously with it. In t vulcanizing outfit shown at Fig. 428, pressure is applied to t patch by means of coil springs, whereas in the Shaler, the pressu to secure intimate adhesion is applied to the tubes by means swivel clamps which produce a uniform pressure on every part

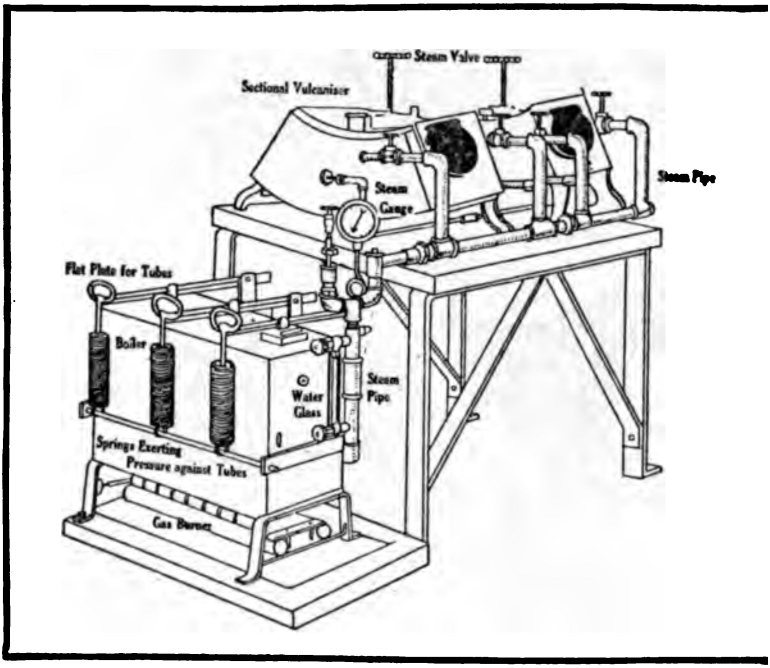


Fig. 428.—Typical Shop Vulcanizer.

the patch. With this outfit the method of making blowout repai is by curing from the inside with the inside casing mandrel ar from the outside with the casing tread form simultaneously. I stead of cutting away a quantity of rubber and fabric, a ree forcement of heavy fabric is built up inside of the casing ar the holes through the rubber are filled with pure Para gum. T *boiler is a copper coil* heated by a powerful gasoline burner w

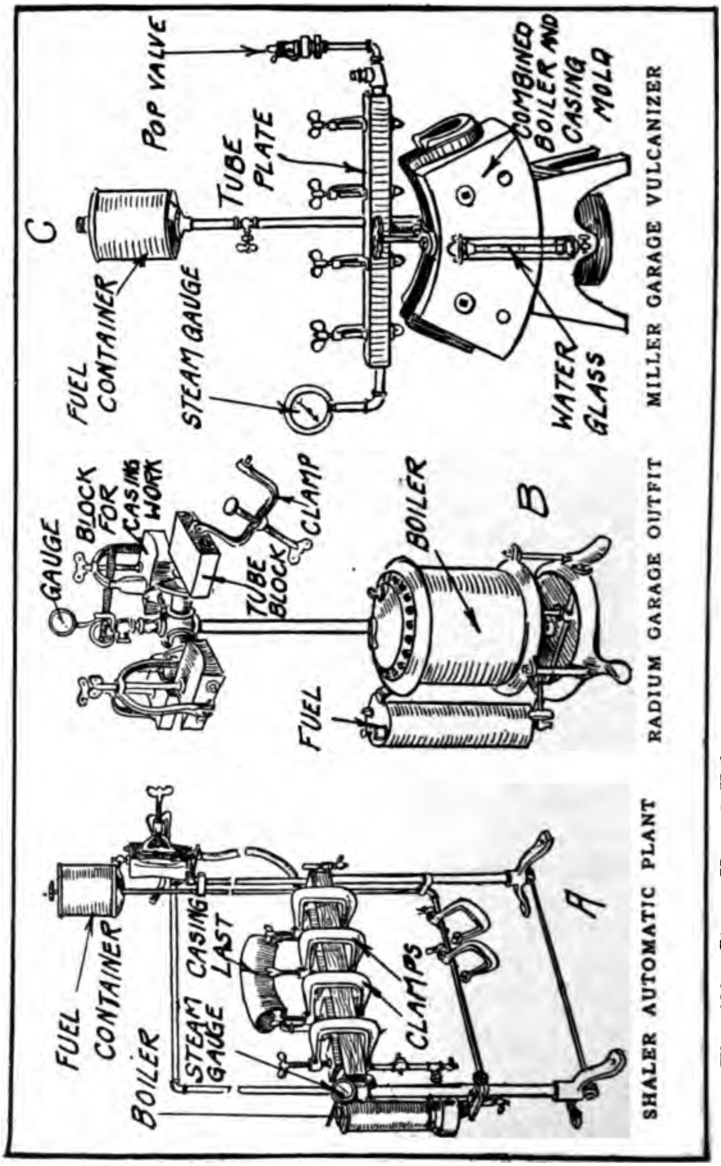


Fig. 429.—Steam Heated Vulcanizers Suitable for Commercial Repairs of Pneumatic Tires.

raises steam to the vulcanizing pressure from cold water in fif-
:een or twenty minutes. A thermostatically controlled damper naintains the pressure and temperature of the steam at the correct 'ulcanizing point automatically. The "Radium" outfit which is hown at Fig. 429, B, is provided with two tube blocks and two asing blocks, these coming from a globe fitting carried at the end f the steam pipe leading from the boiler. In the Miller garage ulcanizer which is shown at Fig. 429, C, the casing mold is com-
ined with the small boiler while the tube plate which has provi-
ion for vulcanizing four tubes at a time is mounted above the asing mold. Attention is directed to the accessories, these in-
luding the steam gauge at one end of the tube plate, the safety op valve at the other and the water glass to indicate the correct evel of water at the front of the combined boiler and casing mold.

The outfit shown at Fig. 430 is of Haywood design, and is nown as the "Hoosier" plant. It is not intended for retreading work but for sectional and inner tube repairs. It is a compactly built equipment with a boiler containing two vertical fire flues capped with a baffle plate to hold the heat down. A steam conduct-
ing pipe leads from the boiler to the steam dome, this having four outlets which lead to the several molds. All molds are of a shape that is self-drained and condensation returns back through the steam supply pipe. It is said that this plant will cure all types of casings ranging in size from 2½ to 5½-inches, that it will cure a blowout up to 15 inches in length and will even cure a tire cut from bead to bead. The tube vulcanizing plate is of ample size and will cure three or four inner tubes at one time.

The various types of molds and the method of using them are clearly shown at Fig. 430, these being intended for use with the vulcanizing plant depicted at the left of the illustration. As will e apparent the mold proper consists of a hollow casting shaped o conform to the tread of the tires it is to fit at the bottom and aving smoothly planed side walls to insure a correct fit of the bead nolds as the fit determines the amount of heat conduction and the uccessful curing of the entire injured section of the casing. The nold is shown at 1 while the arrangement of the mold bead form nd clamp is clearly outlined at 2. Bead molds are made in various

patterns, those at 3 and 7 being intended for straight side ca
while the forms outlined at 4, 5, and 6 are for use with cl
casings. The air bag which is placed inside of the tire cas
sectional work with the usual process of vulcanizing is shown a

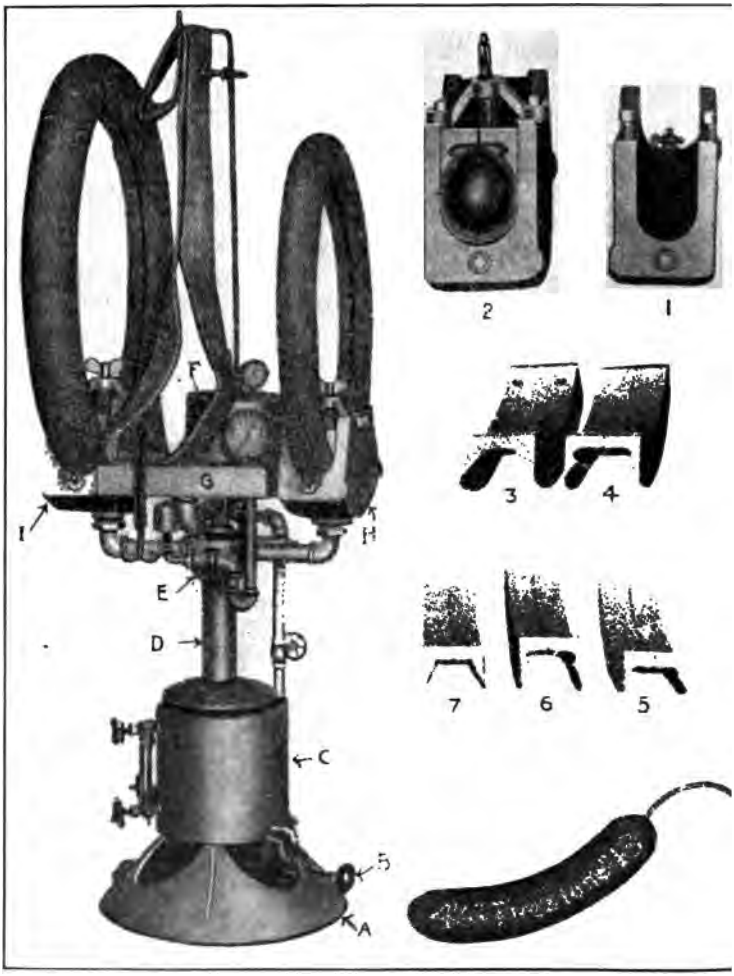


Fig. [illegible].—The Haywood "Hoosier" Vulcanizer and Sectional Mo
for Same.

wer portion of the illustration. This is practically a short sec-
on of heavy wall inner tube provided with an inflating tube and
alve in order that it may be blown up when placed inside of the
asing to press the sides of the casing firmly against the heated
valls of the mold. The mold is heated by the steam circulating
hrough the hollow interior while the bead molds are raised in
emperature because they are in contact with the heated walls.
The clamp serves to keep all parts in secure engagement and makes

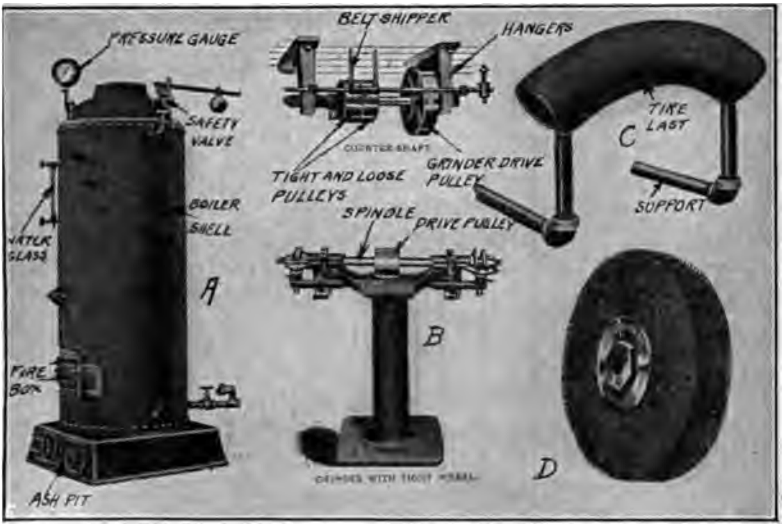


Fig. 431.—Some Useful Accessories for the Tire Repair Shop.

or uniform heating as well as providing a degree of pressure which
s very desirable in vulcanizing.

In some cases the vulcanizing molds are placed on a large table nd the steam is obtained from a boiler of larger capacity than hose ordinarily supplied with the vulcanizers previously described. n a large shop where much tire repairing is done the small vulanizers will not have sufficient capacity so a large number of molds nd tube vulcanizing plates are arranged so they may be supplied vith steam from a large separate boiler. This is coal fired for the nost part and as will be evident by referring to Fig. 431, A, it to

lows the conventional design of the vertical fire tube boiler in making steam for engines and heating purposes. Ther number of supplies that can be included in the shop's equipn facilitate the repair processes. Where much tire repairing i the grinder and countershaft shown at Fig. 431, B, will be valuable because ease with which rubber may be g off of a casin also because of t vantage obtaine roughening the r and fabric with scratch brush as at D in order move all dirt, g etc., and make fo tive adhesion of t ment. The tir shown at C is int to be attached t work-bench by s iron pipe suppor working on casin it provides a resting place stripping down of fabric in n sectional or oth pairs. Some syst method is necessary to take care of the material in process of r A simple tire rack for holding casings is shown at Fig. 432. is very easily made, and obviously the design may be varied that shown to provide accommodations for inner tubes as w casings, the basis of the stand of rack consists of standar pipes attached to the floor and ceiling, the tires being suppor wooden strips attached to brackets clamped to the iron pipe

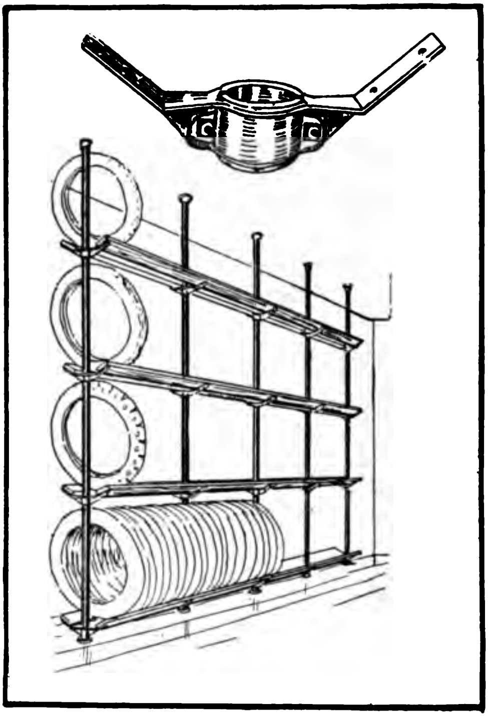


Fig. 432.—An Easily Constructed Tire Rack.

brackets are simple castings and may be moved up and down to accommodate different size casings by releasing the clamping screws, and they are easily locked in position at any desired point on the pipe by tightening the clamping screws.

Materials Employed in Tire Work.—The stocks and compounds commonly used in tire repair work are many and as is true of other forms of construction, none but the best should be employed. Many tire repairmen use cheaper grades of stock because the margin of profit is larger, but this is poor policy, and any one who wishes to establish a business will find that only the best selected material should be employed. If this is bought from reputable makers, at a fair price, there can be no question as to quality. Cover stocks are used for retreading and padding, and vary in composition and gauge from $3/64$ to $3/32$-inch thickness to meet different requirements. Some retreading stock is in the form of thin sheeting, other forms, known as "camelback," are calendered thick in the center so that it answers the same purpose as though several layers of the regular retreading stock were used. "Inside patching" is a rubber stock cured on one side and uncured on the other, made especially for repairing tire tubes. Frictioned fabric is a textile product of high grade long fiber cotton, impregnated with rubber composition, while rebuilding fabric is frictioned material having a skim coat of pure gum in addition. "Bareback" fabric is material frictioned on one side only, while breaker strips are narrow widths of frictioned fabric in various sizes, ready for application to tires without cutting, save for length.

When an inner tube is blown out badly it is necessary to cut it at that point and use what is called a tube splice, this being made with a short piece of tubing with each end tapered that joins the ends of the ruptured tube. Cements vary widely but should always be similar in composition to the rubber upon which they are to be used, as to make a good joint by the vulcanizing process the cement should contain the same percentage of sulphur. This is another condition in which the experienced man scores, as if care is not taken in the selection of the cement, very unsatisfactory results are obtained in vulcanizing. Most rubber cements consist of pure Para rubber dissolved in naphtha or other solvent, to which is

added other substances, such as shellac as thickeners, or various specific driers to make the cement dry quicker. Where tenacity is specially desirable, other gums, such as mastic and gumlac, are used. So many excellent cements on the market have been tried and tested that the repairman would be unwise attempting to compound his own, especially when these can be purchased as cheap, if not cheaper than the raw materials and made on the premises. The results are more uniform with commercial cements.

Many motorists cannot understand why tire repairing is a somewhat costly process, but it will be evident that great care is necessary at every stage, from preparing the tire and applying the fabric and rubber, to the final curing, and that a certain knowledge is necessary which can only be gained by experience. Then the materials employed are costly, the retreading stock costing about $1.50 a pound for a product of the best quality, while frictioned fabric such as is used in rebuilding, costs about $2.50 the square yard. There is considerable hard work needed and experienced men command good salaries. Then the repairman must stand back of his work and often loses money in endeavoring to please customers by making gratuitous repairs upon tire failures which were due to the motorist's abuse, and not that the work is faulty. The pictures and drawings illustrating the subject are pertinent and will serve to make clear some of the processes and apparatus necessary in tire repairing.

Proportioned Repair Stocks.—In buying repair material, a certain amount is to be invested, and this should be for a properly proportioned stock. To get too much of one thing and not enough of another is vexing and discouraging to the man making a start. It is to overcome this drawback that supply houses offer certain assortments, consisting of the right kinds and the right quality of stock. The assortment mentioned below is merely suggestive. The price quoted on each kind of material aws the market price at the time this book was printed. Prices vary slightly from time to time, and a change, therefore results in the amount of each grade to be shipped. The recommendation is made by the Haywood Tire and Equipment Company of Indianapolis, Ind.

ASSORTMENT A—$100.00

30 lbs. AA tread stock	$0.75	$22.50
20 lbs. AD building fabric	1.00	20.00
10 lbs. AS single friction	.90	9.00
5 lbs. MC cushion stock	1.20	6.00
5 lbs. AB breaker	1.00	5.00
3 lbs. MT tube stock	1.20	3.60
5 gals. SLC cement	1.90	9.50
20 lbs. soap-stone	.05	1.00
1 doz. No. 1 Valve bases		1.50
1 doz. No. 2 Valve bases		1.90
100 Air checks		2.65
100 Valve caps		2.00
1 doz. 777 Valves		3.50
½ doz. 725 Valves		1.85
2—3″ Tube sections	.50	1.00
4—3½″ Tube sections	.60	2.40
5—4″ Tube sections	.75	3.75
2—4½″ Tube sections	.90	1.80
1—5″ Tube section		1.05
		$100.00

A much smaller outfit, suitable for the individual owner or mall repair shop follows:

ASSORTMENT E—$5.25

2 lbs. Tube stock	$1.20	$2.40
1 lb. Tread stock	.75	.75
½ lb. Cushion stock	1.20	.60
1 qt. Cement		.70
1 Can soap-stone		.20
1 doz. Air checks		.35
1 doz. Valve caps		.25
		$5.25

How Tires Are Often Abused.—In many instances tires have een received by repairers which show such wear at the sides that e canvas layers are exposed, which is due to three causes, all of hich may be directly traced to abuse by the driver of the car t

which they were fitted. This wear may be caused by (
against the curbstones, in car tracks and with the tires d
In driving many motorists come up too close to the curb, a
friction at the side of the cover naturally causes it to wear
side, so that sooner or later the canvas layers are exposed
usage, if continued, weakens the shoe and a blowout will

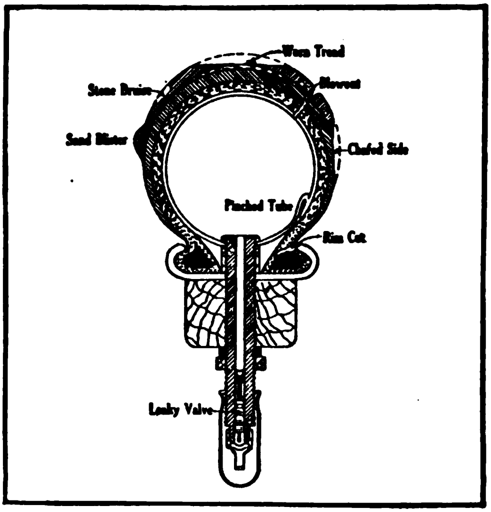


Fig. 433.—Sectional View of Pneumatic Tire, Showing the Defective Conditions Which Demand Attention.

If one drives
tracks the side
tread will wear (
sides, as with th
construction th(
in many cities '
a space betwe
rail and the pa
which the tire
forced, and tl
tion will caus(
wearing of the
at the side
tread.

Other reas(
wearing the s
the cover are t:
to deflated tir
the case of ;
driven car th(
edges of the clincher rim may cut into the casing, this wearir
known as rim cutting, being produced by the concentratioı
entire weight of that quarter of the car upon the edges of
channel. Wearing by the chain of a side chain driven car
ble, if the tire is not properly inflated. It is evident t
weight will depress the tires and if there is not sufficient air
it cannot resume the rounded contour under which condi
clears the chains, and when flattened the sharp edges of
side retaining rivets will shear off the rubber very quickly

Another condition in which many motorists are negl
keeping their tires clean and free from oil and grease, fo

r is perfectly waterproof, it is easily affected by oils and acids, which act as solvents, and if exposed to their action ıy length of time it will soften and disintegrate. The first of decomposition show only when it is too late, that is, when re is beyond repair, and unfortunately there is a tendency ribute this to an inferior quality of rubber, whereas it is irectly to the solvent action of the oil, and the purer the rub-ıe more rapid the chemical action. In many types of live ıxles the oil will leak from the housings and get upon the Often the motorist will let his car stand for days at a time ɔool of oil on the floor of the garage or motor house. Oil l be immediately washed off of any of the rubber parts with ıe or naphtha. The importance of keeping either oil or water from rubber cannot be too firmly impressed upon the man ishes to obtain maximum service at minimum expense from es.

hy a Tire Depreciates Rapidly.—A most common form of ɔration is ordinary wear of the rubber tread, which depends the quality of the rubber used and the number of miles ı; in such a case the fabric, which is really the main support tire, is laid bare. This is inevitable owing to the constant n of the tire against the ground, but many people attribute ear to inferior quality of rubber, forgetting that even the esistent of materials will not constantly endure. If one con- to use a tire worn down to the canvas the fabric will wear y, and the shoe be weakened so that the walls no longer re-.e pressure of the inner tube, which bursts out through the ned portion. After a tread is worn to the canvas, deteriora-ill be rapid and the only possible repair is the application ew rubber tread.

ıother cause of tire depreciation is small cuts in the rubber ng which will affect the fabric as well. These are caused by objects, such as broken glass, nails, particles of iron, flints, stones, etc., which stick into the tire. The damage caused e of two different natures, either the outer cover is cut to a r or less depth or both the cover and the inner tube are cut ;h, the tire being temporarily rendered useless in the latter

instance, which is the "puncture" that is the dread of moto

Assuming a sharp object has cut a gash into the cover, bu not reached the inner tube. In such an event, especially i layers of fabric have not been damaged the driver can go o the moment without repair. It is different when one or more o layers of canvas have been cut into. In that case water, sand, etc., work into the cut and cause the tire to blister while will produce rotting of the fabric, either of which conditions i given immediate attention becomes fatal to the outer cover. will work between the layers of rubber or fabric and produce b known as sand blisters, which often puzzle the driver and giv to all manner of surmises as to their cause.

Water Rots Fabric.—The average motorist does not us consider water an enemy to tires, and it is not so long as it outside. Moisture has very little effect upon the rubber, but ages canvas to a great extent. Cotton fabrics and in fact all table fibres which have as a general basis cellulose, such as jute and hemp, can offer resistance remarkably well to atmosp influences such as oxygen, heat and damp, which affect so organic substances. For instance, it is said that a piece of exposed for a month in the air, the sun and the rain, doe lose more than two per cent. of its original strength and pieces wetted and ironed dry 20 times in succession only lost per cent. If left under water for six months, the cotton fabri does not lose much of the dynamic force although the water may be covered on the surface with mold. But if cotton i in a damp place, on the damp floor of a cellar, for instance, get spotted in a very short time, on account of the mold, scopic fungi, mildew, and other minute agents of destruction. effect is well known to motorists as wall papers, which are made of cellulose fibres, will fall to pieces and crumble when walls of damp rooms or closets. It is this same result which causes bursting of tires apparently in good condition, th time used after standing all winter, because the cotton fal rotten. This has been proven by testing the canvas, the red of resistance being 50 to 75 per cent. of its original value b of the weakening of the fibres due to the chemical actio

ınce of keeping water from the interior of a tire should rent, and this can be best done by keeping the tires properly , so that the beads will hug the rim, forming a water-tight ·eing that all tire and valve lugs have suitable washers under s, that the valve is provided with suitable packing washers, tly that all cuts size which pene- › the fabric are ith new rubber anizing.

cribing Repair es.—In describ- thods of resto- eference will be o the processes eading, rebuild- aking sectional and simple in- be work. Re- g is necessary he outer tread worn through use that the shows in spots, can only be vith profit on that are strong, ch the fabric

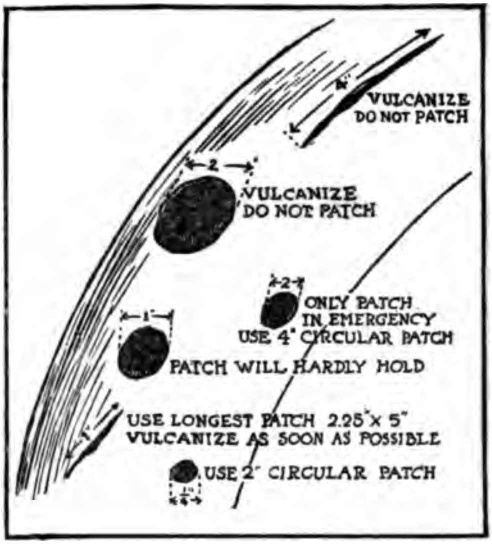


Fig. 434.—View of Inner Tube, Showing the Various Sized Holes and Sizes of Patch to Use in Making Repairs, also Defects that Cannot be Patched but Must be Vulcanized.

or body has not been weakened by blowouts or rim-cutting. ing a tire is replacing weakened or destroyed fabric by new l and making a new tread. It is a more expensive opera- l is seldom profitable. In case of a large puncture or blow- casing (providing the rest of the shoe is in good condition), ly necessary to build the tire over at the weakened spot. known as sectional work and is perhaps the most common of repairing known. Tube work is simple and the method ; upon the size of the hole to be sealed. The necessary mr

terial and stock may be purchased but experience can only tained by constant endeavor to improve, and knowledge most important asset of the successful tire repairman.

Tire Tube Repairs.—Tire tube work includes repairing tures, blowouts, cuts due to pinching in application, or by fitting security bolts, and inserting new valves. After locati opening, the rul slightly roug with a piece of cloth for an in a half on all s the hole, the is cleaned thor with benzine, cei filled in with canized stock patch and cure flat plate. Ci treated as pre described to ins solute cleanline edges are cemen brought together with unvulcanized stock to form a unic cured, as in the case of a simple puncture. Blowouts o punctures require different treatment after the rubber ha thoroughly cleaned, as the size of the hole seriously weak tube. The area around the opening is well cemented, both and out, inside patching material is placed inside the tu space between the edges of the hole filled in with unvul material, stitched carefully, placed on a flat plate and cured length of time in heat is governed by the quantity of mater quality of the tube to be cured. This will vary from 10 minutes at a steam pressure of from 35 to 50 pounds. In ing valves a piece of rubber known as the valve pad is vulc to the inside of the tire instead of the inside patching, this as a reinforcement and forming a firm base for attachment valve.

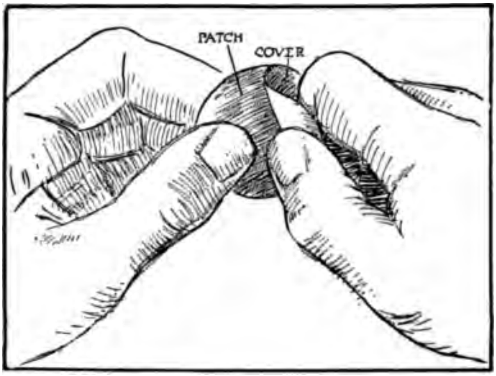


Fig. 435.—How to Remove the Cloth Cover to Expose Cemented Surface of Prepared Patch for Inner Tube Repairs.

ıg **Valve Stems.**—There are a number of occasions valve stem of an inner tube becomes defective due to tripping of the external threads so that the pump con-not be securely screwed on, stripping of the valve thread h prevents the removal of the check valve and bending s due to careless handling in removing it from the rim. ımmon fail-ıring off of ions on the e by which ıded to be ·ed, which t the valve taken out :omes leaky. any one of ·cts tempo-·oys the use-the inner hat member ıtively new rviceable, a stem may be ·rted. The who does will find it

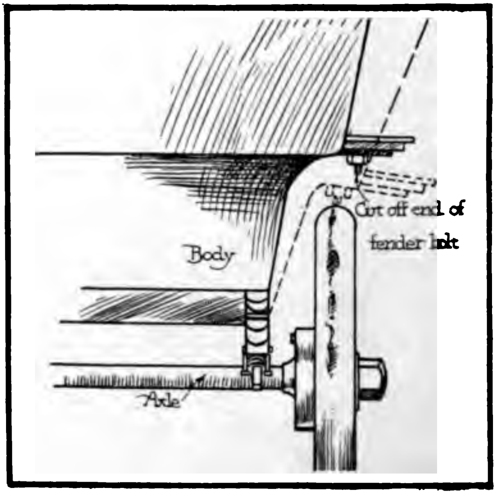


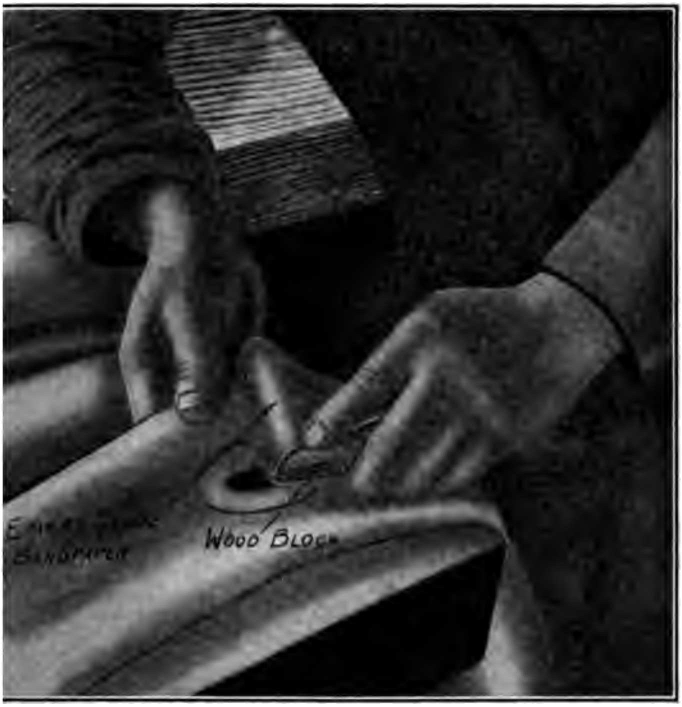
Fig. 436.—How Tire Tread is Sometimes Injured by Projecting Bolts of Fender Iron if Springs Deflect Excessively.

us to cut out all the valve stems from old inner tubes be in his possession, and even when an inner tube is en-out the valve stems may be in good enough condition to ·ing them until an opportunity presents itself for using efective valve stem may be taken out of the inner tube uring it by releasing the clamping nut and removing it ing spreader, then removing the corrugated washer which ıbe against the button-shaped inner end of the stem. The the tube adjacent to the stem can be carefully loosened tton end separated from the rubber by forcing the stem ıe. Some gasoline or naphtha may facilitate loosening

the valve base if cement has been applied. If a pair of sp
pliers is at hand their point can be inserted into the hole and
can be stretched until it is sufficiently large to pass the butt
the stem through. The button end of the new valve ster
placed in a hole when this is elongated and some cement m
plied to the contracting surface of the stem end as a lub

Fig. 437.—Showing Method of Locating Punctures in Inner Immersing it in a Tank of Water, the Escaping Air Indic Presence of the Leak by Bubbles.

entrance into the interior of the tube. The pliers are then
and the tube allowed to constrict around the valve stem.
ent is placed on the corrugated face of the clamping
en the spreader is put on over the stem and the clamp
ed down and tightened. By partially inflating the tube



—Showing Method of Cleaning Area Around the Puncture with ry Cloth or Sandpaper Before Applying Cement to Tube.

erging the stem portion in water one can easily determine
actory repair has been effected. Care should be taken in
the clamp plate or spreader so that its greatest length
wise of the tire. The function of this is to protect the
e point at which the valve is attached. It also aids in hold-
sing in place on the rim to some extent.

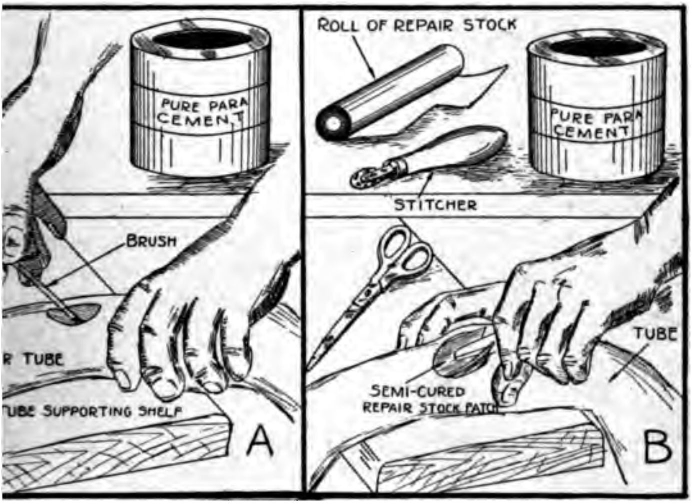
Simple Casing Repairs.—In event of a damaged shoe, the e
tent of damage and whether the hole is through the cover, or on
through the rubber is ascertained. If only the tread is affected
will not be necessary to remove any of the canvas layers, but t

Fig. 439.—Showing Use of Wire Bristle Buffing Wheel Attached to Spi dle of Small Portable Drilling Machine for Cleaning Area Su rounding Puncture on Inner Tube.

rubber must be cut away for one or two inches around the brol
surface. The edges cut bevel, then roughened with a rasp or em
wheel; then apply two or three coats of vulcanizing cement, all
ing each to dry thoroughly and build up with cover stock to s
face contour, dust talc over the mold, clamp tightly, and vulca

Repairs May Be Made From Inside.—If the hole is throu
the tread and body, and it is not too large, such as is caused b
simple puncture, a good deal of work can be done from the insi
of the tire and very little rubber need be removed from the tre

ıple puncture no rubber need be removed. For a small it is only necessary to fill in that part of the tread or cover ; blown away. In making repairs from inside it is neces- turn the casing inside out, and remove two or three plies ; inside, "stepping down" each ply, as shown at Fig. 443, ply to be within two inches of either side of the edges of . Clean thoroughly and apply at least three coats of vul-



).—Preparing Inner Tube for Vulcanizing Patch. A—Coating ɔr Wall of Tube with Rubber Cement. B—Inserting Semi-Cured air Stock Patch.

cement, allowing each coat to dry thoroughly before ap- ıe next. This will require about an hour for two first coats ·e hours for the last. Cover the inside of the fabric with ; unvulcanized stock, turn the tire back as it should be and the fabric removed with new stock by a "stepping-up" applying one or two extra layers of plies in the inside ex- for several inches beyond the other material, this to make ir as strong as any other part of the tire. Fill in the out- face with raw stock, place the tire in a sectional mold,

Fig. 441.—Showing Use of Stitcher in Rolling Patching Rubber t Firm Contact with Inner Tube.

both mold and tire over with talc powder, and after plac-
ıir bag or substitute inside the shoe inflated from 40 to 60 pressure the curing follows. It is recommended that the wrapped at each end of the mold for about six inches with ge, this to hold the case together and prevent distortion or out of the air bag. The curing continues from 45 minutes our at from 50 ounds, accord- the size of the

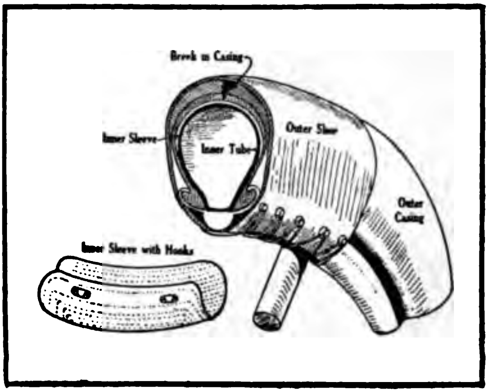


Fig. 442.—Showing Method of Using Inner Sleeve and Outer Shoe in Making Temporary Repair of Blowout in Casing.

ther method of this repair, and l if the blow- at all serious, emove the old or four or five n either side of ıing. The tire restored with k, after the in- s been treated ously described kened or broken fabric replaced by a stepped series of lay- esh material. A point that must be observed is to remove a t quantity of the tire stock to insure that fabric enough osed on the shortest step, which is that next to the cut, so will bridge over the hole and leave a substantial margin of at either side. As it must be evident that there is consider- ain against the patched portion of the tire, the greater the r which the stress is distributed the stronger the repair. y of fabric or rubber should be well rolled with the stitcher every part of it will adhere, and if air is left between the forming bubbles, these will cause loosening of the covering e tire is in service. Air pockets should be struck open with t of an awl moistened with water before making a hole, as s will close together more readily if this precaution is taken.

eading and Rebuilding Tires.—If a tire has become worn

through normal wear, it is possible to put a new tread on fabric body and add considerable to the life of the tire. tread a tire the first operation is to remove all the old trea to the fabric. This is done by cutting straight across and to the first breaker strip, and pull this away from the tire using gasoline or benzine to assist in loosening it from the p

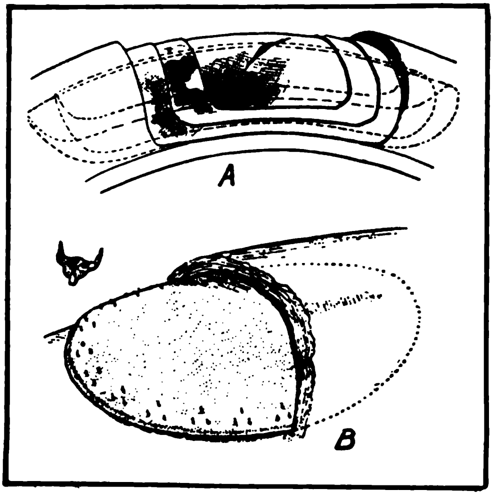


Fig. 443.—At A, Method of Stepping Down Fabric and Tread of Outer Casing when Repairing Blowout by Sectional Vulcanizing Process. At B, an Inside Patch that is Held in Place by Mechanical Means Instead of Cement is Shown.

The remaining is cut away sharp knife m in water, and traces of the o are removed wire brush, wheel or rasp. fabric has be aged, as somet sults when the run with th worn so that are exposed, jured layer sh cut off. After the outside of is thoroughly with gasoli when this has rated three c vulcanizing cem applied, allowing the last one to dry about three hours. of 20-gauge cover stock is applied as padding, and over placed a breaker strip, then another layer of cover sto used as padding, this covering the breaker strip only. O padding is applied a sheet of 60-gauge retreading stock, a it to extend one inch each side of the breaker strip; apply a layer of the same stock about one inch narrower, and over laid another strip of retreading stock of the same gauge others which extends to the point formerly the edge of

. Each ply is rolled thoroughly and stitched and all air is ıed from air blisters. The shoe is now ready for curing. ebuilding is very similar to retreading except that new fabric d to replace any that is not up to the standard in the body rcass of the shoe. The tread is removed as in retreading, and rst ply of fabric is cut through all the way around on the

444.—Showing Method of Stripping Off Worn Fabric from Section f Old Casing to Make a Very Satisfactory Inside Patch for Blown- Out Casings.

of the tire. After cutting, this ply is turned back all the round to within one-half to one inch of the bead. The weak- plies are removed, never more than three, as more than this the cost of this mode of restoration prohibitive. Assuming wo plies are removed, cut out the first all the way around ı one-half inch where the first ply is turned back. Remove ext ply within one-half inch of the second and clean the tire ıghly, applying three coats of cement. It is imperative that

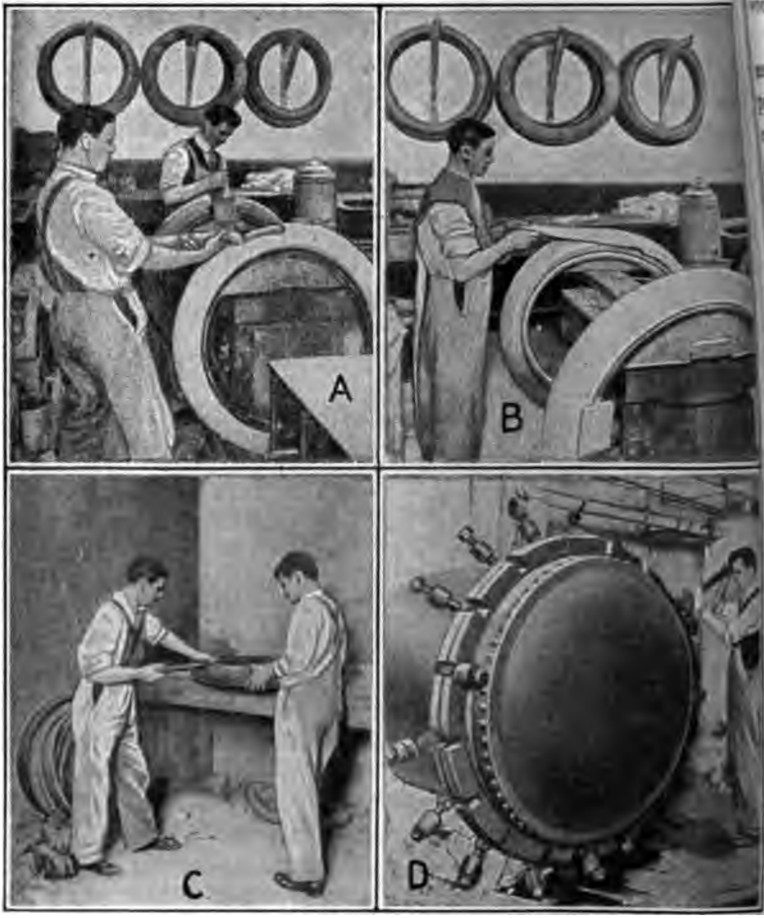


Fig. 445.—Depicting Various Steps in Retreading Casing. A—Stripping Off Defective Tread Rubber. B—Applying New Cover Stock. C—Wrapping the Casing Firmly with Strips of Cloth. D—Bolting on Cover of Steam Oven Retreading Type Vulcanizer.

the cement coatings dry thoroughly. Twenty-gauge cover stock is applied over the cement and rolled thoroughly, and rebuilding ...ic, cut on the bias, is used to replace the plies previously removed. The part of the tire that is turned back is rolled into proper position, the union at the edges being made with unvulcanized pure gum stock, and the remainder of the process is the ame as in retreading.

Many rim cut clincher tires are brought in, the damage resulting from use without sufficient internal air pressure, and in some nstances it is possible to make a very satisfactory repair upon hese. The rubber is removed from the cover on the side for about n inch and a half or two inches above the bead and then a ply of bric is removed about one-half inch from the toe of the bead. If ore than one ply is cut the next ply should be cut away one inch ore than the first. Clean thoroughly and cement. Twenty-gauge ver stock is applied, the rebuilding fabric to take the place of ch layer removed, the last ply to be cut wide enough to turn inde the casing from two to three inches. An amount of unvulanized stock about equal to that removed from the cover is then pplied and the tire is ready for curing.

In tire retreading or rebuilding, certain essential factors, if obrved, will insure success. The parts must be thoroughly cleaned fore application of cement, and all coats should be allowed to dry least the time specified by the makers. Every layer of material plied, whether fabric or rubber stock, must be firmly rolled to ure proper adhesion, and it is imperative that air bubbles be ctured and the air released. The best cements and stocks to are dictated by experience, and the gauges of the stock aped will vary with the individual preference of the repairman, ough these should be chosen with reference to the material in the re that is being restored.

To cure a rebuilt or retreaded cover in the large pot heater it s necessary to have air bags of the proper size for each tire, as hose that are too large may become pinched, while those too small ill not properly fill the interior of the casing. After an air bag which is in reality either a portion or entire specially made tire ube) is placed in the case, the tire is assembled on the rim and

wrapped spirally with a bandage of sheeting or light duc three inches wide. Next the air bag is inflated to 40 or 50 pressure, and the tire is placed in the heater and cured, th of curing depending upon the size of the repair, varying minutes to one hour and at pressures of steam varying fro

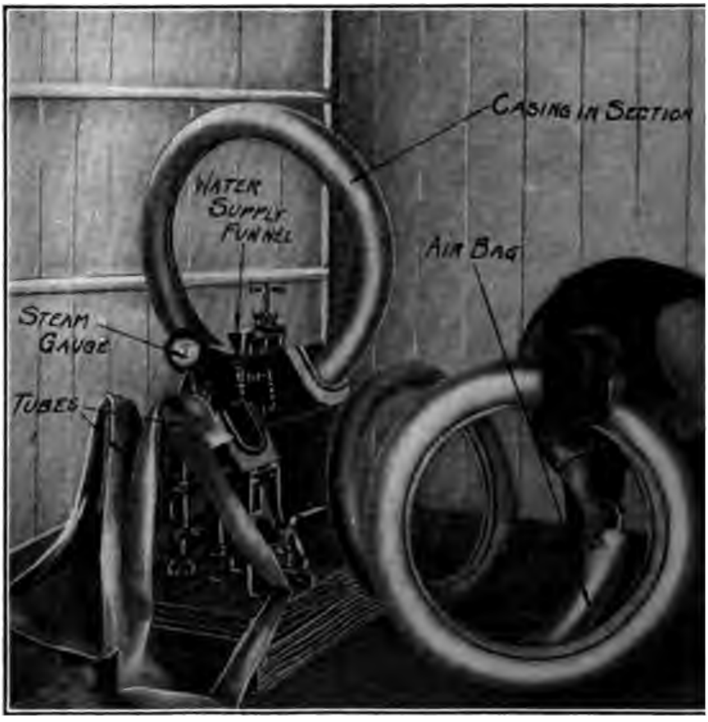


Fig. 446.—Corner of Typical Repair Shop, Showing Practical A tion of Vulcanizer on Both Tube and Casing Work. Notic tion of Air Bag in Casing Before Putting Same in Sectiona

50 pounds. In curing special care must be taken and in t cess many inexperienced operators make error. If a casing i too long the rubber will be too hard and will lose resiliency while if the curing process is hastened and the tire is not heated, the rubber will be soft and repair unsatisfactor

removing the tires from the heater they are allowed to cool about 30 minutes, then unwrapped and hung up for a day or two to set. Steam at a pressure of 40 pounds has a temperature of about 250 degrees Fahrenheit and is the heat commonly used in curing rubber.

Dry Cure Methods.—There are two systems of vulcanizing when making sectional repairs or retreading, that best adapted for general use being the dry cure system in which the desired pressure for vulcanization is secured with pads instead of with an air bag and where the tire is cured by the application of heated elements rather than wrapping it and placing it in a steam oven. A number of molds used in the dry cure system and sold for use with the Haywood vulcanizer have been previously described and illustrated in connection with that outfit at Fig. 430. Additional appliances are shown at Fig. 448. That at A is known as an inside patch or relining mold and may be used in relining, patching or for drying out the interior of a casing before a reenforcement is started. On blowout work, especially of the larger and more difficult class, it is often necessary to apply two or three layers on the inside of a tire, and although considerable heat is conducted from the outside mold it is well to give the repair a twenty minute cure on the inside which is best accomplished with the form of mold shown at A.

Solid pads and clamps are used in connection with the various types of Haywood molds for obtaining pressure on the curing stock. These pads conform to the curvature of the mold on which they are used. There are a number of advantages given for the pad and clamp system, over the air bag system. It is said that the properly built pads last indefinitely, whereas the air bags have a definite life and are subject to the uncertainty incidental to the use of pneumatic appliances. With a solid pad on one side of a repair and a substantial accurately machined mold on the other and with three to five heavy iron clamps drawing the two together it is possible to exert more pressure on the curing stock than by any other system and pressure is considered an essential to good work. The pad and clamp system is simple and easy to operate and there is nothing in its operation that calls for skilled labor. It not only produces considerable pressure on a repair but also localizes the heat to the portion being repaired.

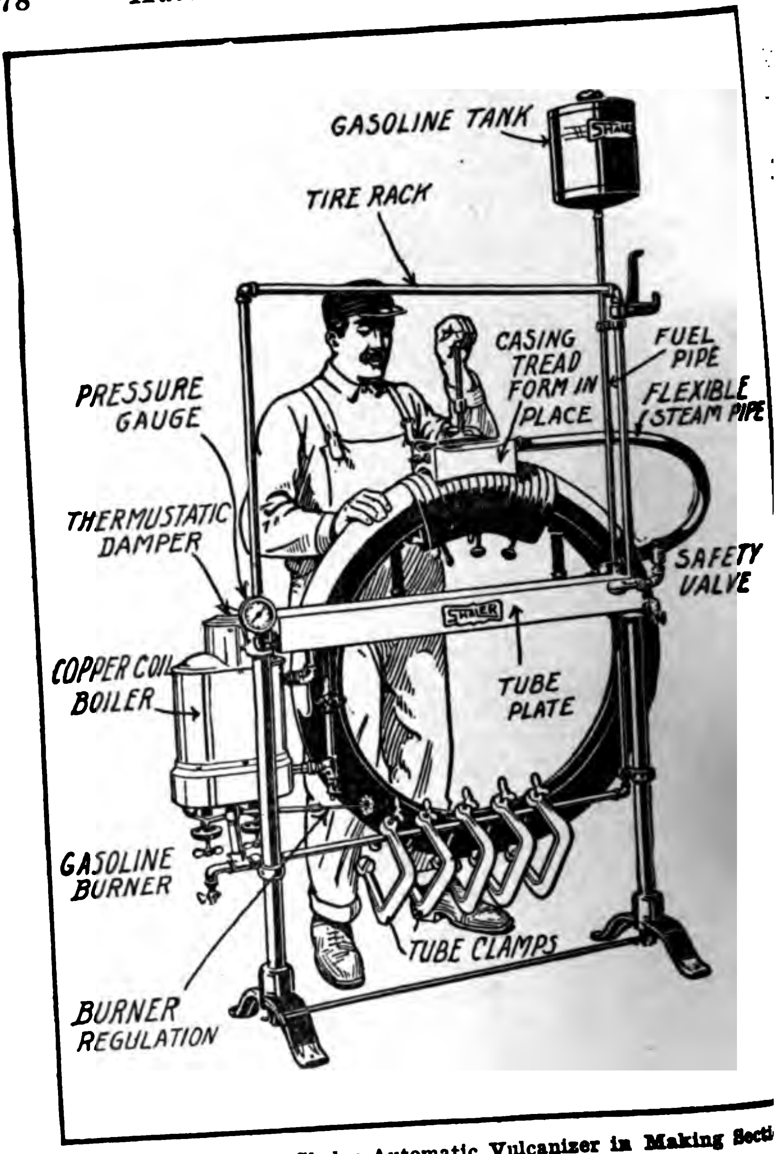


Fig. 447.—Use of the Shaler Automatic Vulcanizer in Making Secti
Repair on Outer Casings.

The method of using the pressure pad in making a repair on defective tire bead is shown at Fig. 448, B. The side wall and be mold is shown at C, while the appearance of a repaired portion a casing having a long rim cut and blown side wall is shown at Retreading may be also easily accomplished by the dry cure meth The appearance of a tire needing retreading is clearly shown Fig. 449, A. This is only practical if the layers of fabric are good condition. The old tread is stripped off as previously

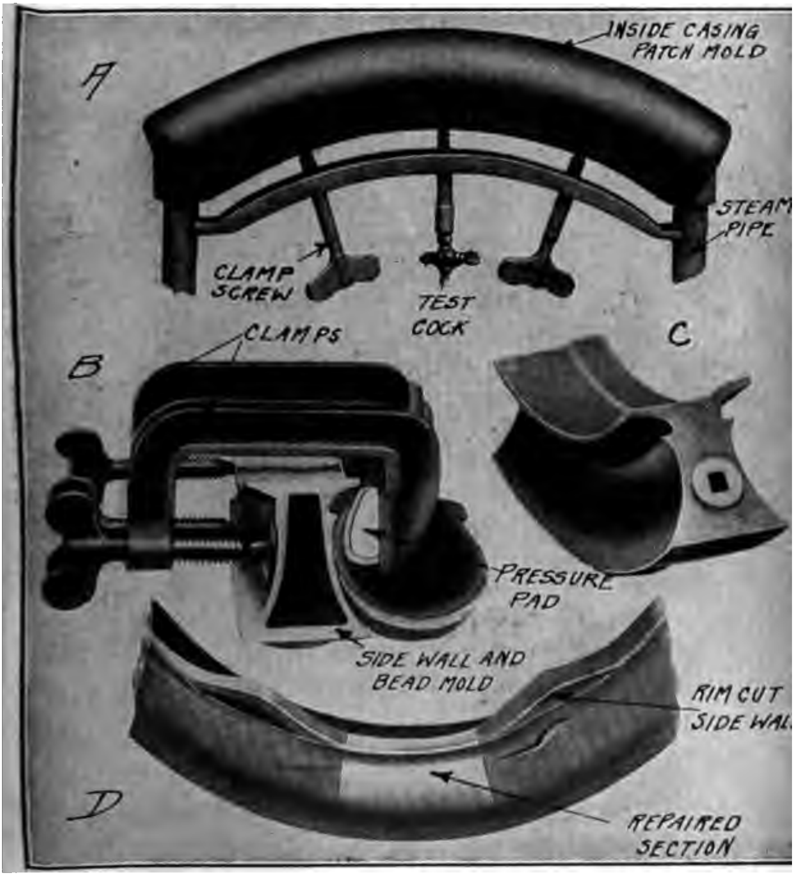


Fig. 448.—Molds for Use with Dry Cure Process of Vulcanizing.

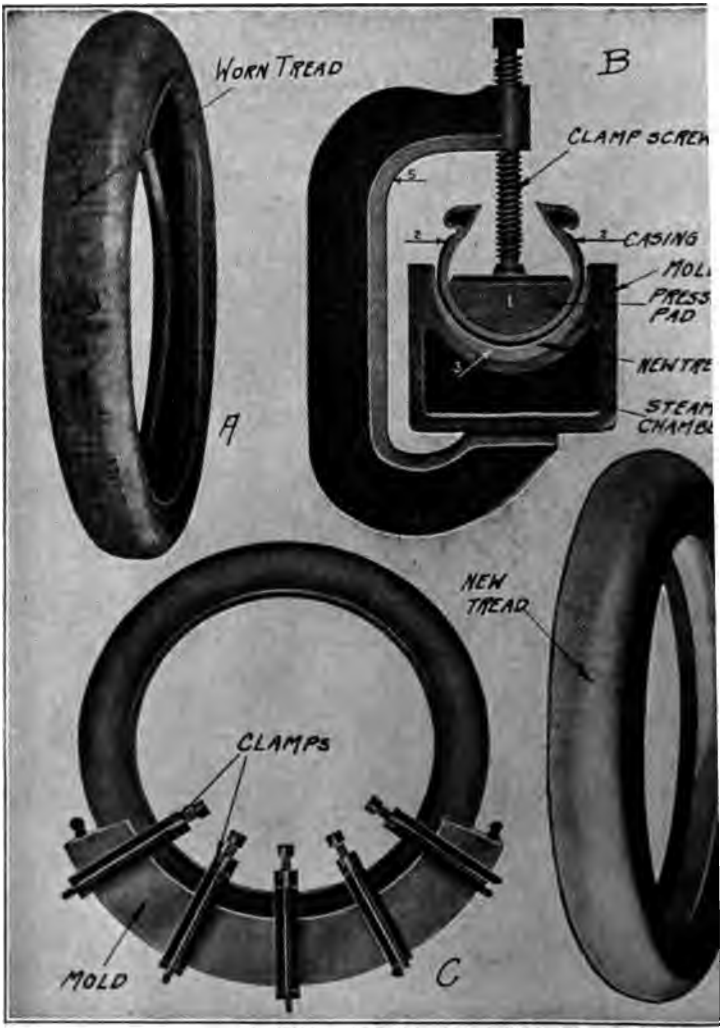


Fig. 449.—Showing Molds, Clamps and Pad Used for Retreading a by the Dry Cure Process.

scribed and the new tread cemented on and vulcanized by the use of a retreading mold which is shown at Fig. 449, C. The retreading molds are 26 to 28 inches in length and heat approximately one-third of the circumference of the tire at one time. The molds are hollow, allowing steam circulation from one end to the opposite and have an opening at the lowest point to exhaust the products of condensation. The sectional view of the mold with the clamp and casing in place shown at Fig. 449, B, shows the construction of the mold and the method of applying the new tread very clearly. The appearance of a retreaded tire after the new tread has been cured on is clearly shown at D. Sectional molds, which are the forms previously described are simply short retreading vulcanizers. They are used for curing the tread portions where the injured section is not long enough to call for the use of the retreading mold shown at C. Sectional molds are the forms to use for surface cuts, sand-blisters, stone bruises, short patches of loose tread and other defects confined to a specific area of the tire.

Reconstructed Tires.—A new method of tire salvage has been recently devised by which two old casings may be combined to form a new casing, this being especially desirable when one of the casings has a good bead but a poor tread while the other one may have a good tread but be defective at the bead. This process is called reconstruction to distinguish it from retreading as it consists of stitching the two tires together in such a way that they cannot separate, using the one with the best bead for the inside member. The entire feature of the repair lies in the stitching process, and as this is not an easy one a number of firms are in existence which have special machinery for doing this work. Sometimes the process includes adding a special layer of calendered fabric to the surface of the inner tire. Another process includes the addition outside of the second tire of a non-skid surface composed of steel studs fastened into a special fabric, this being firmly cemented to the casing.

The appearance of reconstructed tires is shown at Fig. 450. In one process the procedure is substantially as follows: the cover is first subjected to examination and if found satisfactory for repairing is transferred to the stripping machine which strips the whole

of the remains of the old rubber tread from the canvas base. cuts, bruises or bursts are then cut clean and built up with fabric and rubber and the cover is then treated to a proce forces a rubber compound under heavy pressure into the between the layers of canvas where movement between the produced separation. To the whole of the inside of the cov or two layers of specially prepared canvas are applied, the

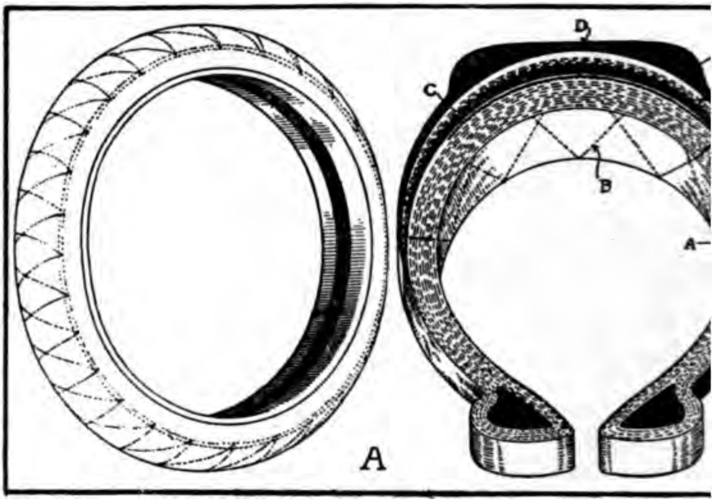


Fig. 450.—Method of Combining Worn Tires and New Material t duce a Reconstructed Casing Capable of Giving Considerable tional Service.

being put into a special sewing machine which covers it with work of stitching which runs through the entire carcass, t ducing the internal movement of the layers relative to each to a minimum. A final lining of friction canvas is attached inside over the stitching. The stitching and treatment up point form the basis of the patent which protects the ma turers repairing by this process. The illustration at A in the stitching of the inner cover before the outer cover is a The view at B shows the completed unit with the other tr place and fastened to the inner cover. In this view A ind the old cover with its tread removed, B, the cross sewing

›ining rubber, D, the new tread, E, dark rubber forming the new 'ead, F, light rubber and canvas forming the base of the new ead. After the cover has been stitched as shown at Fig. 450, A, e next stage is to treat it to a generous layer of rubber compound ı the outer side and the prepared jointless tread is carefully fixed place. The cover is then filled with molds which are hammered to place to stretch the cover base into its original shape and ap- oximating as near as possible the shape it assumes under working ılation pressure. The next process is the wrapping and binding the cover. This is then followed by treatment in a vulcanizer ›m whence it emerges with the tread attached to the original can- s base by a thick layer of resilient black rubber. It is said that ɜ life of a reconstructed tire is often equal to that of a new one ıereas the cost of reconstruction is but 50% of that of new tires most cases.

Repairing Punctures with Mechanical Plugs.—Repairmen who ,ve had experience in bicycle work are thoroughly familiar with e advantages as well as the limitations of the screw down plug ıich has been widely sold for repairing single tube bicycle tires. modification of this form of plug has been introduced for use ı inner tubes and has the advantage of being very easily handled ough its use is limited to the repair of small punctures. The plug ɪelf consists of two threaded discs of metal which are firmly vul- ınized in a surrounding mushroom shaped mass of rubber. The wer one of these has a stem attached to it on which the upper ɜad is threaded. The plug is clearly shown at Fig. 451. For otorist's use these are sold as a kit with a set of special pliers to ıcilitate manipulation. The first operation after the puncture is cated is to use the conical punch end or cutter as indicated at C, hich makes a smooth round hole that is not apt to tear. The next ›eration is to stretch the hole as shown at D in order to permit ıe insertion of the lower portion of the plug. After this is in lace the upper part is kept from turning as shown at Fig. 451, E, y pressure of a finger, while the lower portion is brought tightly ɔ bear against the inner tube which is sandwiched between the two ɪarts of the plug by turning the bent part of the stem which acts as ʌ lever and makes possible the secure retention of the inner tube

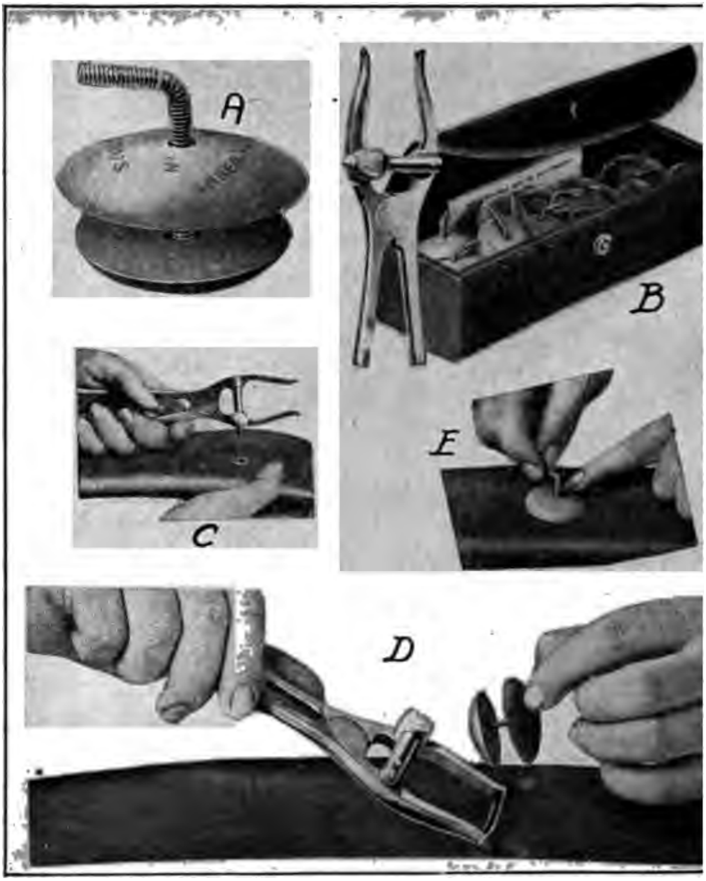


Fig. 451.—How Inner Tube Punctures May be Repaired with Sampson Mechanical Repair Plug.

between the upper and lower portions of the plug. Afte parts have been tightly screwed together, the projecting the threaded stem is broken off or cut with the pliers and projects it is smoothed down with a file. In order to prev plug cutting through as would be the case with metal pl edges of the rubber pieces are very flexible and soft w course, prevents them cutting into the inner tube.

PRESSURE AND CARRYING CAPACITY PER WHEEL OF STANDARD SIZED PNEUMATIC TIRES

veights in excess of 1.000 pounds per wheel, 5-inch tires or larger nmended.

ize, ches	SINGLE: Extreme Load per Wheel, Pounds	SINGLE: Air Pressure Recommended, Pounds	DUAL: Extreme Weight per Wheel, Pounds
36x2½	225	40	
36x3	350	50	
	400	60	
	450	60	
	550	60	
d 36x3½	600	60	
	550	75	
	650	75	
	700	75	
	750	75	1200
	700	85	
	900	85	
	1000	85	1350
	1250	90	1500
	1350	90	2000
	1500	90	

CREASE IN AIR PRESSURES CAUSED BY DRIVING

igures given by tire manufacturers as the most suitable for initial generally take into account the increase in temperature and pressure by prolonged running. It, however, is useful to know what this is. The figures in the following table are given by a French y and are averages computed on tires from 3 to 4½ inches diameter sual touring car weight and speed conditions. For larger tires the is greater on account of the greater rigidity of the cover walls, re- n greater internal strains in the fabric at the points of bending.

Pressure in Tire, Cold. per Square Inch	Working Pressure in Tire, Warm. Pounds per Square Inch	Increase Resulting from Work. Pounds per Square Inch
71.116	88.183	17.067
85.339	105.750	20.411
99.562	123.546	23.984
113.785	141.920	28.135

MAXIMUM CARRYING CAPACITIES OF SOLID TIRES

SINGLE		TWIN	
Size, Inches	Extreme Load per Wheel, Pounds	Size, Inches	Extreme Load per Wheel, Pounds
2	500		
2½	750	2½	1900
3	950	3	2500
3½	1375	3½	3500
4	1750	4	5000
5	2000	5	6000
6	3000	6	8000
7	4000		

METRIC TIRES AND THEIR AMERICAN EQUIVALENTS

Metric Sizes	Approximate Size in Inches	Metric Sizes	Approximate Size in Inches
650 x 65	26 x 2 ½	870 x 90	34 x 3 ½
700 x 65	28 x 2 ½	910 x 90	36 x 3 ½
750 x 65	30 x 2 ½	960 x 90	38 x 3 ½
800 x 65	32 x 2 ½	1010 x 90	40 x 3 ½
830 x 65	33 x 2 ½	815 x 105	32 x 4
860 x 65	34 x 2 ½	875 x 105	34 x 4
700 x 85	28 x 3 ¼	915 x 105	36 x 4
750 x 85	30 x 3 ¼	820 x 120	32 x 4 ½-5
800 x 85	32 x 3 ¼	850 x 120	33 x 4 ½-5
860 x 85	34 x 3 ¼	880 x 120	34 x 4 ½-5
760 x 90	30 x 3 ½	920 x 120	36 x 4 ½-5
810 x 90	32 x 3 ½	1020 x 120	40 x 4 ½-5
840 x 90	32 x 3 ½	1080 x 120	42 x 4 ½-5

CHAPTER XI

MISCELLANEOUS REPAIR PROCESSES

xy-acetylene or Autogenous Welding—Torches for Welding—Sources of Gas—Cost of Autogenous Welding—Instructions for Operating—Welding Cast Iron—Method of Preheating—Welding Aluminum—Welding Malleable Iron—Welding Brass and Bronze—General Hints—Treatment of Steel, Annealing—Box Annealing—Hardening—Pack Hardening—Tempering—Case Hardening—Distinguishing Steel from Iron—Hardening Steel Tools—Temperatures for Tempering—Molten Metals to Produce Desired Heat—Working Iron and Steel—Annealing Chilled Cast Iron—Bending Pipe and Tubing—Filling the Tubing—Pipe Bending Fixture—Straightening Out Bent Fenders—Removing Dents in Tanks—Soldering and Brazing Processes—Fluxes for Soldering—Solders and Spelter for Different Purposes—Lead Burning—Soldering Aluminum—How to Braze Iron and Steel—Testing Lubricating Oils—Evils of Exhausting in Closed Shop—Instructions for Repairing Storage Battery—Care of Grinding Wheels—Speeds for Grinding Wheels—Grading of Grinding Wheels.

MANY men are engaged in the automobile repair business who ave been specialists in some particular branch of mechanical work efore becoming interested in the automobile. Wood workers, lacksmiths and carriage smiths are especially noted owing to the ecrease in carriage and wagon work and increase in automobile epairing. The review of various mechanical processes which follows cannot fail to be of value to all those not thoroughly familiar ith all branches of mechanical work. Even the automobile mechanic will find the material useful for review.

Autogenous Welding.—Autogenous welding is the process of niting metal surfaces by heat without the aid of solder or compreson. High temperature, full control and easy application of the eat are necessary requisities. The most satisfactory method is ermed the oxy-acetylene process, the flame having a temperature

of about 6300 degrees Fahrenheit. By this process iron, steel, cast iron, aluminum, brass, copper, platinum and other metals may be so perfectly united as to defy detection when the joint is smoothed. Its uses include the following: Reclaiming light and heavy castings coming from the sand with blow holes, sand holes, cold shuts and lugs off; reclaiming light or heavy cracked or broken aluminum; adding metal to parts subjected to friction; repairing large or small frame members in place, welding in new parts or filling in cracks; welding split piping or flanges on pipes; reclaiming imperfect steel castings; extending short shafting, adding small metal parts broken off or missing and renewing teeth broken from gear wheels. This process is of inestimable benefit to the automobile repairman and every first class mechanic should have experience in handling the welding torch. Its uses in the repair shop are legion.

The operation of cutting steel or iron is by heating the metal at the first point of contact to the red with the ordinary welding flame. This flame is then continued with a jet of pure oxygen turned on, which unites with the carbon of the metal and disintegrates it with surprising rapidity. The cut is narrow and smooth, with no material damage by oxidation. It may be made in any shape, and the process will be found especially valuable in making many kinds of dies and in fitting steel plates. Steel beams in structural work, steel arches, steel boilers, steel piling, shaped deck plates for steamships and the hardest steel vaults may be cut with ease. The secret of the process lies in the high temperature of the flame, which increases the temperature of the metal so rapidly that very little heat is diffused into the body of the part, most of it therefore being available for fusion. The number of heat units actually absorbed by the metal is a very small fraction of that required to bring the same part to a brazing heat with the ordinary gas or oil blowpipe, and very little if any warping takes place.

One of the first points to be understood when considering the use of autogenous welding is that the heat actually has to come in contact with every particle of metal welded. It is impossible to weld by this method where this cannot be done. If a small boss is required on a given casting, it is useless to cut out a disc of metal the same size of the boss with the idea of welding it on. The cor-

ect way would be to add metal drop by drop, until the required ize is reached. The torch is the most important factor in auto- enous welding and cutting. The type generally admitted to be f the best construction consists of two small pipes or conduits erminating at one end with hose connections, the other entering recess head that receives the torch tips. The pipe for acetylene s screwed into a cylinder about one and one-half inches in diameter, 'hich serves for a handle, and is packed in porous material that revents the possibility of communicating a flame beyond that oint.

Torches for Welding.—It is not generally known that three istinct types of torches have been invented for oxy-acetylene weld- ng. These are termed respectively low, medium and high pres- ure, taking their name from the relative pressure under which the cetylene is used. The high pressure torch was never introduced nto this country owing to certain disadvantages, finally causing he medium pressure torch to be brought out. The low pressure orch was invented by Edmond Fouche, and its principle is based n that of the injector, the acetylene being drawn by suction pro- luced by the flow of oxygen, which is under pressure. The acety- ene is brought to the torch under a pressure of a few ounces per quare inch only. The flow of oxygen is regulated by the area of nozzle and by its pressure so that the correct proportion of acety- ene is sucked in. The mixture then passes out at the burner or tip f the torch.

The size of the orifice in this tip is of great importance, as it ontrols the resistance in the mixing chamber to the flow of oxygen, nd therefore controls the proportion of the two gases. As is well nown, the amount of fluid sucked by an injector is proportional the square of the velocity of the propelling fluid. It is therefore ssential that the flow of oxygen should not vary or the proportion f acetylene would not be constant. For the low pressure torch his proportion is 1.7 oxygen to 1.0 of acetylene by volume, at at- nospheric pressure and any variation in either direction will pro- uce either an oxidizing or carbonizing flame. The flame should, herefore, be carefully watched as the orifice in the tip may be ex- panded by the heat being deflected onto the torch, or it may be

contracted by particles of metal adhering to the tip, thus el the mixture. Owing to the fine adjustment of the injecto these torches are often made without any means of vary size of the flame, it being necessary to disconnect the tor the hose and substitute another one, when it is desired to a number of torches being required if it is necessary to all classes of work. Owing to the low pressure, the speed

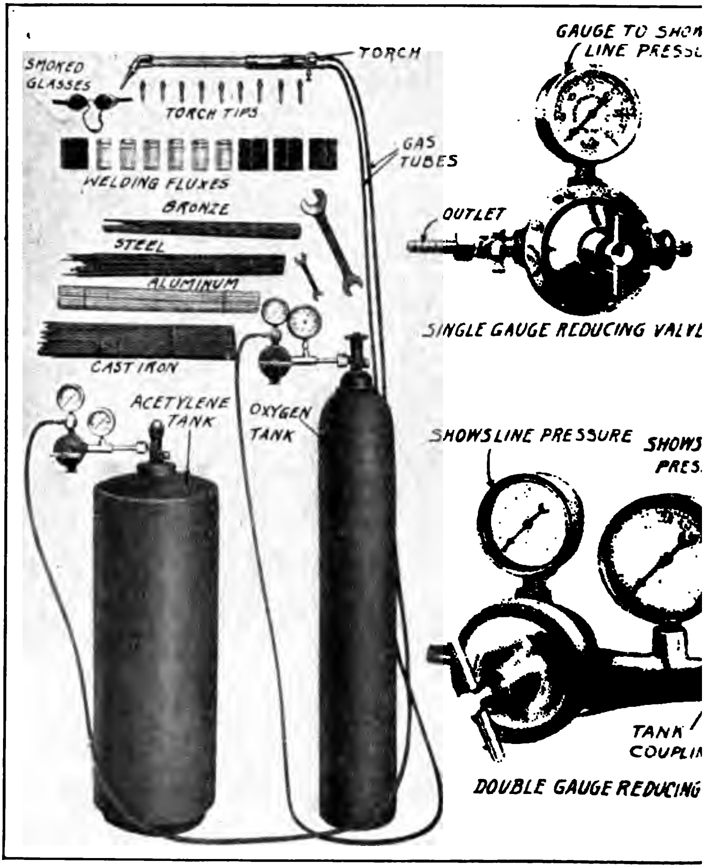


Fig. 452.—Complete Welding Outfit Suitable for Repair Shop U Note Appearance of Automatic Reducing Valve.

suing mixture is very little above the speed of the propagation : the flame and "back fires" frequently occur, the gas has then › be turned off, lighted again and the mixture readjusted. The ·dinary acetylene lighting generator supplies gas at a pressure ıitable for use with this torch.

In the medium pressure torch, both the acetylene and oxygen ·e under an appreciable pressure, which results in a constant mixıre under all conditions, the proportion being 1.00 of acetylene to 3 of oxygen. The mixture is regulated by holes at the inner end : the detachable tip, and is not affected by any variation at the ıter orifice. The pressure of each gas is kept constant as required r adjustable reducing valves in the pipe lines. The speed of the ıs is greater than in the low pressure torch and back firing is pracically eliminated. If the flame goes out, it can be relighted withıt altering the gas adjustment.

Sources of Gas.—The source of oxygen and acetylene gas suply is a question which requires careful consideration for each inividual case separately. It can either be generated at the plant, or ın be shipped in steel cylinders from one of the several companies ho are generating and compressing it.

The points to be considered are:

1. The transportation charges for the compressed gas and cost : the cylinders.

2. The quantity of gas used and, therefore, the number of cylin-ers that would be required to contain it.

3. The regularity of the consumption, depending on the regu-rity of the work, and also of its size.

4. The cost of generating the oxygen at the plant.

The first depends upon the locality and shipping facilities, as ell as in the quantity of gas that will be used. The second also epends on the first, with the consideration that the cost of cylin-ers might equal or exceed the cost of the generating plant.

The third might necessitate the generation of oxygen at the ant, anyway, particularly if repairs were the principal work rried out as unless the supply of work were regular and all of nall size, one could not depend on keeping a sufficient supply of ygen on hand, and this class of work is generally required im-

mediately, and cannot therefore wait for shipments. The depends on the quantity of the chemical that could be bougl time and the cost of its transportation, and also on the a of establishment charges that would be figured in.

It will be evident that the best method for the garage shop is that which involves the least expenditure as the amc

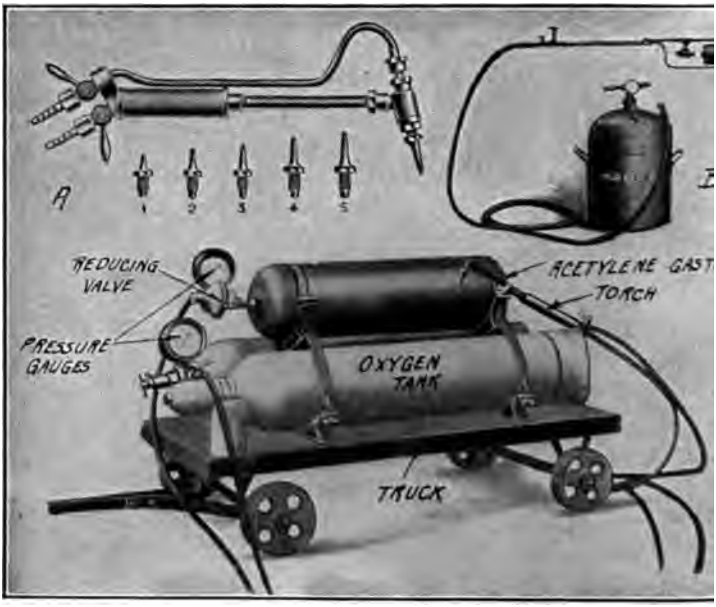


Fig. 453.—Torch for Autogenous Welding and Tips for Same at A. heating Torch at B. Portable Welding Outfit on Wheeled 1 Shown at Bottom of the Illustration.

work done would not be sufficient to warrant the installati an oxygen generating plant using the usual mixture of chlor potash and manganese dioxide. The acetylene gas may be r obtained through the almost universal Presto-lite service and gen cylinders are also easily available.

The matter of cost of welding by the oxy-acetylene proce pends upon many factors, and estimates can only be given b

ɩirman after he has had considerable experience with the pro- Some work requires preheating and careful manipulation, ɜ must be clamped to prevent distortion, in such cases the cost he jig or fixture is apt to cost more than the welding.

CAPACITY OF CYLINDERS

All cylinders are charged at 150 lbs. pressure

Diameter Inches	Length, Inches	Capacity, Cubic Feet	Weight, Pounds
7	24	50	50
8	30	80	75
10	30	125	105
12	36	225	120
14	48	400	349
16	48	500	435

Che following table gives an approximate idea of the cost of ling under the conditions stated:

APPROXIMATE COST OF OXY-ACETYLENE WELDING

ygen at three cents. Acetylene at one cent per cubic foot. Labor at 30 cents per hour.

Thickness of Metal	Consumption of Acetylene per Hour	Consumption of Oxygen per Hour	Linear Feet Welded per Hour	Cost of Labor per Hour	Total Cost per Hour	Cost per Linear Foot
	Feet	Feet	Feet	Cents		
$\frac{1}{32}$ to $\frac{1}{16}$	2.8	3.6	50	30	$0.43	$0.008
$\frac{1}{16}$ " $\frac{3}{32}$	4.5	5.7	30	30	0.51	0.017
$\frac{3}{32}$ " $\frac{1}{8}$	7.5	9.7	25	30	0.66	0.026
$\frac{1}{8}$ " $\frac{1}{4}$	11.7	15.0	16	30	0.86	0.045
$\frac{1}{4}$ " $\frac{5}{16}$	18.0	23.0	10	30	1.17	0.117
$\frac{5}{16}$ " $\frac{7}{16}$	25.0	32.0	7	30	1.51	0.216
$\frac{7}{16}$ " $\frac{1}{2}$	32.5	41.5	5	30	1.87	0.374
$\frac{1}{2}$ upward	48.5	62.0	..	..	2.64	.....

Instructions for Operating.—The following instructions are ɩ *from the literature* of the Welding Apparatus Company of

Toledo, Ohio, and while intended to apply to the "Monard welding outfits manufactured by this concern, the processes m be followed with almost any of the garage type welding outfi offered by reputable manufacturers.

1. See that all gas connections are tight, using soap suds discover leaks, if any.

2. Upper side of torch is for oxygen. Acetylene connecti should be made to lower side of large handle.

3. When all connected up ready to light torch, turn regulat out, so there is no tension on spring and they are closed. T turn both tank valves open full. Open both valves on torch full turn or more; turn on acetylene slightly and light at tip; t turn on more until blaze has left tip slightly; then turn on oxy same way until small white inner cone is formed in blaze. blaze pops and goes out this denotes that not enough acetylene too much oxygen, is being used. The flame should have a s inner cone from 1/4 inch to 1/2 inch in length with an outside fl of larger proportions.

4. Welding should be done at the end of the small white c

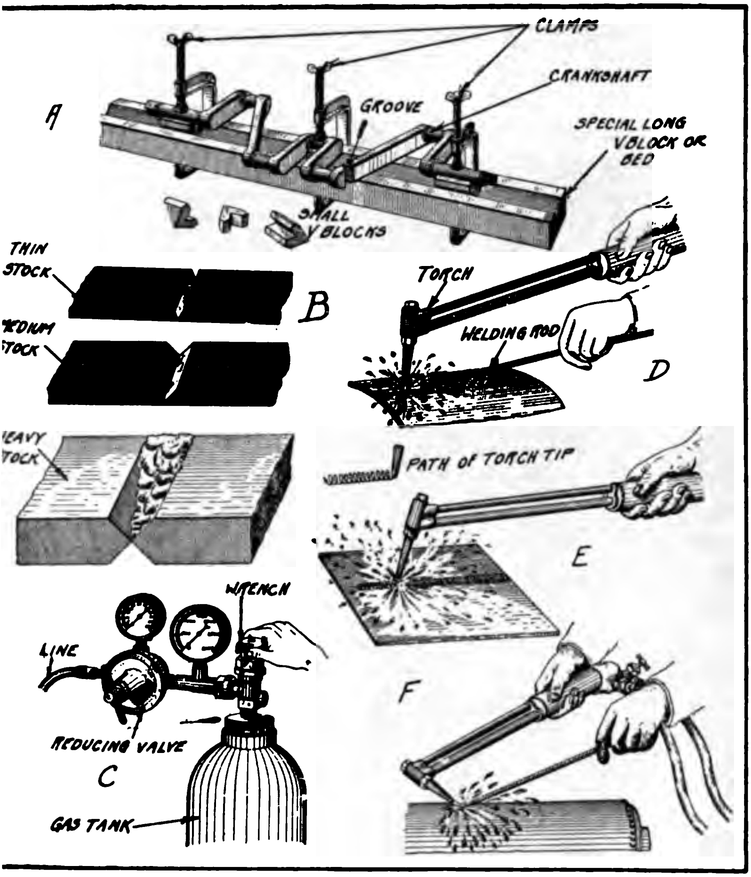
5. In case there is a faint outline of a larger cone, the acety tap should be closed slightly, which will bring this cone just in the small white cone, producing a neutral flame proper for a cessful welding. (Opening oxygen will give same result.)

6. Blow pipes are adjusted for the proper working condit and no sharp instruments should be used to clean out the wel tips.

7. Practice should begin on lighter sections of metal and g ually work up to the welding of the heavier sections.

8. When working on heavy work, water should be provide which to cool the welding tips. Leave the oxygen tap open to pel steam formed. Do not plunge, but dip several times to g ually direct the heat to the tip. Otherwise you may crack welding head.

Welding Cast Iron.—In welding cast iron, such as automo cylinders and machinery parts of similar character, it is neces to preheat the part which is to be welded to a temperature wh is slightly below a dull red heat, if there are no parts that



ig. 454.—Illustrating Various Steps in Autogenous Welding Operation, Such as Preparation of Work and Manipulation of Torch. A—Method of Holding Crankshaft When Welding Broken Web. B—Forms of Grooves for Welding Various Thicknesses of Stock. C—Showing Method of Attaching Reducing Valve to Gas Tank. D—Method of Using Welding Rod. E—Showing Path of Torch Tip. F—Filling a Hole by the Autogenous Welding Process.

jured by such heat. This heat should be applied gradually and ıen the whole object has been sufficiently preheated, the welding be done. There are two reasons for preheating. First, to save

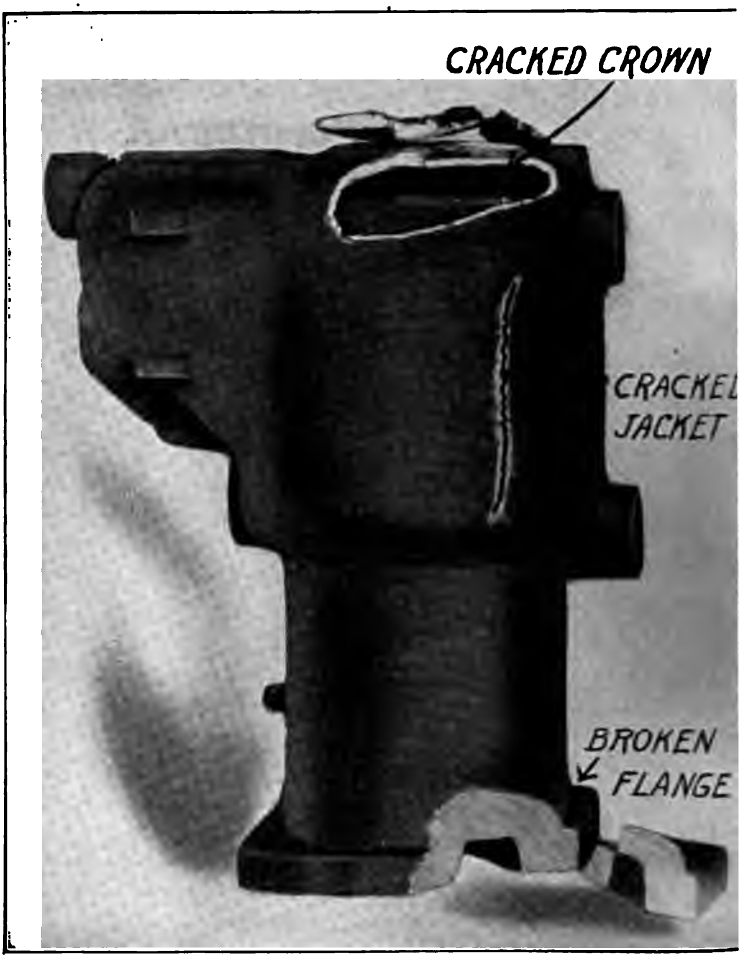
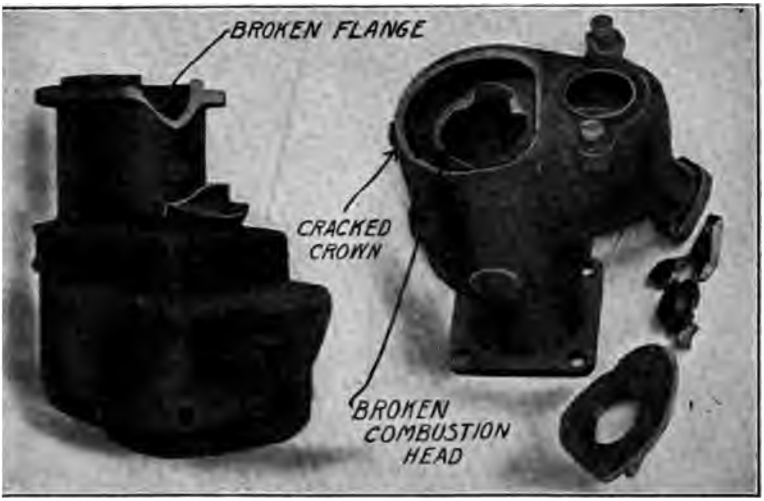


Fig. 455.—Illustrating Principal Cylinder Defects that May be Read Repaired by Autogenous Welding Process.

gas, and second, to relieve strains, due to uneven expansion a contraction of the part being welded. Great care should also used to see that all castings cool slowly after welding, as many good weld has been spoiled by too rapid cooling. A box of li

ashes should be provided in which to bury the casting so it will
ol slowly.

Method of Preheating.—Where city gas of some kind, together th compressed air, are both obtainable in the shop we recommend ry highly a preheating blow pipe using this fuel. It makes an ·al outfit and in fact will be found just as efficient as the other eheaters herein shown, and will answer any and all purposes



ig. 456.—Examples of Defective Cylinders that Were Repaired by Autogenous Process. Cylinder Flange at the Left was Repaired at a Cost of $7.50; Cracked Crown and Water Jacket at the Right Repaired at a Cost of $12.

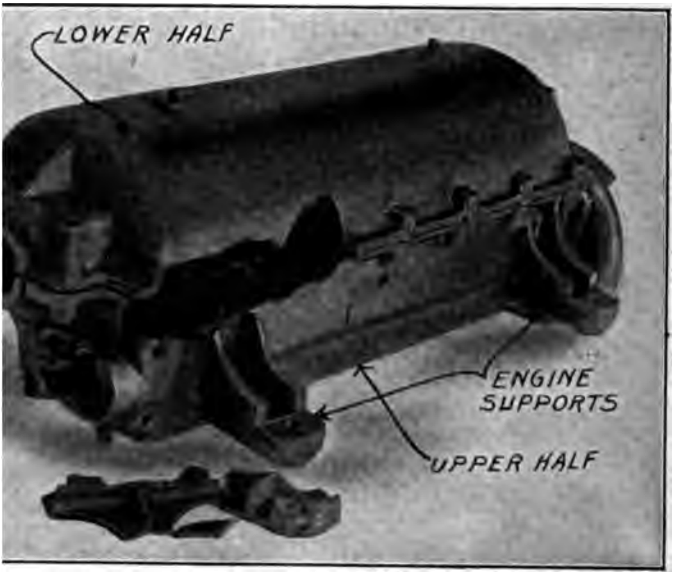
which the oil burning preheaters might be applied. Of course, iere fuel gas and air are not both obtainable in one shop we commend the oil burning outfit shown, although they are slightly gher in price, but, as stated above, where the shop is so situated to be fortunate enough to have both compressed air and fuel s of some kind the gas preheating torch will be found to be very *isfactory, as the first cost,* and also the cost of maintenance, is . *The furnace or muffle* is then built of fire brick to a suitable

size for the particular part we are about to weld. A removal cover is used of asbestos board or sheet metal.

After the welding has been done, the object should be heat again in a similar manner as the preheating was done and th allowed to cool off slowly in the muffle. This is necessary to preve cracking due to the local expansion and contraction, caused by th local heat of the welding flame. This method is also useful i obtaining a softness of the material in the weld. This method o handling welding of cast iron will prove a saving of from 30 t 50% of the cost of gases used for welding. There is nothin particularly difficult in the handling of the welding flame in con nection with welding cast iron, but it should be borne in mind i welding of heavy sections, that the fractured portions should b tapered out in order that the welding can be commenced at th center of the section, building up as the welding proceeds. A flu is necessary for use in welding cast iron and will be found to mak the metal flow more readily and at the same time, flux out the sand dirt, grease, etc. Be sure that the sides of the fracture are i molten condition before filling material is added.

Welding Aluminum.—The welding of aluminum requires con siderable skill and experience before successful work can be ex pected on intricate parts. The manner of making the weld is slightl different from that used with welding of cast iron, due to th fact, that when aluminum is heated, an oxide film is formed, whic prevents the metal running together and forming a suitable wel To overcome this, the aluminum filling rods must be inserted in the molten aluminum, which is being welded, and moved abo rapidly, something similar to puddling, in order to break up th oxide film and allow the aluminum to run together. A flux h also proven of advantage in this connection, where before, prac cally all of this work was done without the use of a flux. A larg tip is necessary for welding a section of aluminum than would required for the same section of steel or cast iron. This is due the fact that aluminum conducts heat away very rapidly. Wi the proper size tip in use, it is necessary to melt a considerab portion of aluminum, which is being held in shape by the fire cl form. Now the extra metal can be added from the filling rod an

puddled with this rod to break the oxide film which forms
ninum is melted. A flux has been provided for use in
ction and will be found very valuable for breaking up
In fact, by using this flux, bosses can readily be built
desired point. This is something that could not be
re a flux for welding aluminum came into general use.
ecautions should be taken to have the work securely
r harnessed, for instance, when welding a hole in the



-Example of a Broken Crank Case Repaired by Autogenous Welding Process at a Cost of $35.

crank case, it is customary to clamp a shaft, which ap-
the size of the bearings (plus, of course, the thickness
metal bearings, which would melt out when preheating,)
rank case bearing supports, in order to insure perfect
of the bearings. Angle irons are bolted to the flanges
nection is made to the other half of the crank case in
sure perfect alignment of this part.

It is good practice to place a sheet of paper on the inside of case next to the crack to be welded. This paper prevents fire clay from getting into the crack. Upon this is placed fire in plastic condition which is held in place by means of asb fiber. This makes a light backing or mold for the case and be easily handled without fear of the mold or core being so h as to break down the case when heated for welding. This should be large enough to cover sufficient area around the c so that the aluminum will not break down.

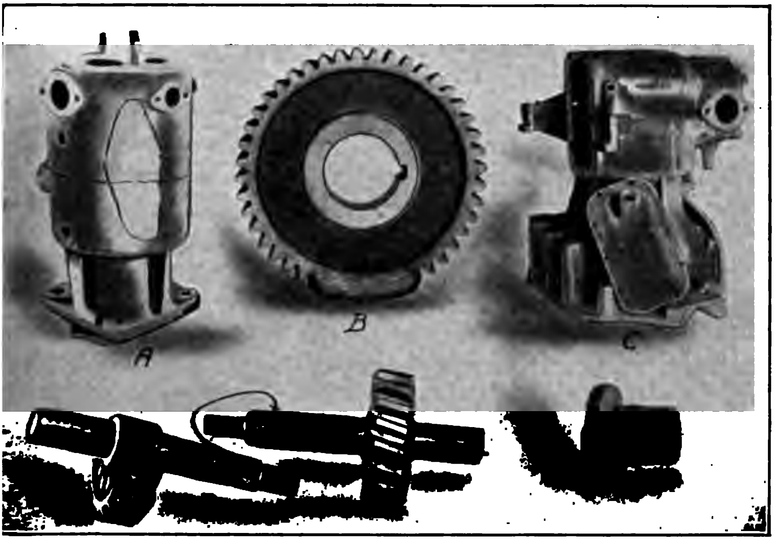
Aluminum parts must always be preheated and handled similar manner as automobile cylinders, as outlined before, the exception that aluminum, of course, should not be heate such a high temperature, on account of the fact that withi degrees C. of the melting point, the metal is very brittle without strength. It is customary to heat up these cases thorou until they will melt half and half solder in wire form. This perature is about right to prevent cracking occurring on acc of expansion and contraction and at the same time, the alumi will possess sufficient strength so that with ordinary handling trouble is experienced with alignment or failure of the part.

Welding Malleable Iron.—Parts of malleable iron are han in much the same manner as cast iron parts in preparation welding. It is customary to re-enforce the malleable iron wel much as possible by building up the section at the fracture. filling material used is usually nickel steel in the bottom of weld, finishing the top surface with cast iron rod. The la runs better and makes a smoother finish.

In some instances you may find that the fracture will be thro a tapped opening, in which case, it will be necessary to cape portion out entirely, making a much larger opening than the itself and then filling this with cast iron, using the same precau in welding cast iron to have this portion soft. Wherever the u is made between filling material used and the malleable iron, will find this so hard that it will be impossible to drill or mac in any way except by grinding.

In some cases in making repairs on malleable iron parts, i even necessary to strap these parts by means of wrought iro

teel straps welded to the body of the casting. In any event, bear ı mind that the heat necessary to melt the malleable iron will estroy the properties of the malleable iron, which were put into ıe part when annealed in the furnace. Consequently it is necssary to use a stronger filling rod and increase the section.



ig. 458.—Examples of Repairs Accomplished by Autogenous Welding Process. A—Cracked Water Jacket Restored at a Cost of $6.50. B—New Metal Applied to Replace Broken Teeth on Transmission Gear at Cost of $1.50. C—Cylinder Water Jacket Repair Costing $12. D—How Worn Keyway on Steering Sector was Filled with New Metal for Recutting at Cost of $1.25. E—How Worn Special Steel Bushing was Restored to Efficiency by Filling Grooves with Metal at Cost of $1.25.

Welding Brass and Bronze.—The preparation of brass and onze castings for welding is similar to that for cast iron castings. ıe fracture must be caped out so that the welding can start at e center, the groove being filled with metal melted from filling d. The filling rod should be of approximately the same mixture the part to be welded. Brass should never be used as filling

material for bronze castings, and a strong weld expected. I dered borax or boric acid may be used as a flux. A mixture o borax and ½ boric acid gives good results. In welding bras bronze the work is carried out as for welding cast iron. The n surrounding the groove is melted and the filling material ad drop by drop, as it is melted from the rod. Be sure the met the casting is in a molten condition, otherwise an imperfect will result. Brass welds can be easily spoiled by burning the out of the composition. Care should be taken not to heat bey the melting point. Flux should be used freely. If the we portion has been burned, it will be exceedingly porous.

General Hints.—Be sure the welding flame is neutral. Be the part to be welded is set up properly. A poor set up may s the best weld for practical use. Proper heat treatment before after welding is as important as good welding, when intricate c ings, such as cylinders and crank cases are being repaired. A hard spots in cast iron welds by preheating before and annea afterward. Take care in using sufficient heat in welding and do make the union between casting and filling material too sharp defined. Do not allow drops of metal to fall on partially mo metal. Use the best grade of filling material. The best are n too good when all the expense of the repair may be lost by a w weld. When preheating aluminum castings for welding, do not tempt to heat in one place only. Keep the burner moving to spr the heat uniformly. In welding steel be careful that the metal at the weld does not weld together and leave a space that is not wel A "V" shaped groove will prevent this. The accompanying il trations show clearly the apparatus and method of manipulat the torch in doing various classes of repair work, also some typ automobile parts that can be saved by the welding process and of accomplishing the work. The photographs of automobile p were furnished by Henry Cave, of The Welding Company, Spri field, Mass., one of the leading authorities on this subject.

Treatment of Steel, Annealing.—Many varieties of steel hard when the process of manufacture, especially if rolling hammering is involved, is completed, these being principally t and special metals. In order that they may be worked with

ıch trouble by ordinary machine tools it is imperative that e soft, and this condition is obtained by a process known as ing. While steel can usually be bought annealed cheaper t can be treated at the factory or shop where it is to be ıed, sometimes conditions materialize that make it necessary eal metal to facilitate work and to reduce stresses upon the ıe which completes the finished product. This process not akes the steel softer, but also removes the internal strains, or ıdency of the metal to crack and spring when hardened. rains are caused by the rolling or hammering processes in el mill or forge shop. When the metal is a forging or blank rly finished size, it is customary to remove part of the surу taking several rough cuts, after which the piece is ready nealing. In order to soften steel it is necessary to heat it to ɔrm red heat and allow it to cool slowly, which process can ·ied on by several methods.

c **Annealing.**—The method commonly followed when the are of large size is known as box annealing, and for this ent it is necessary to have an iron box and furnace of suffiapacity, as it must be obvious that to do this work in a manmmercially practicable it will be essential to treat a considquantity at the same time. These are placed in the containpacked in wood charcoal which has been ground or pounded nall pieces. A layer of this material is first placed on the of the box to a depth of an inch, and then follows a layer steel, then another layer of charcoal, then more steel and

: pieces of metal should not come within a one-half inch of ther or within an inch of the walls of the container at any and the spaces should be filled with charcoal, the metal being l with another layer of packing material about an inch in This method of packing is repeated until the box is filled, eing taken that all pieces do not touch each other or the alls. A tight-fitting cover is then applied and the seams are to exclude the direct heat of the furnace, by fire-clay. l test wires are placed through the top of the box, which thdrawn from time to time to see if the contents are of the

proper temperature. The heat should be maintained a s length of time to insure a uniform temperature, and the the pieces should not be allowed to go over a full red. A box and contents have been maintained at the desired temp for the proper length of time, the heat is shut off and th allowed to cool slowly, the metal being left in the contain cold.

Two Simple Methods.—Often in shops there are no f for box annealing and other methods may be used, thou

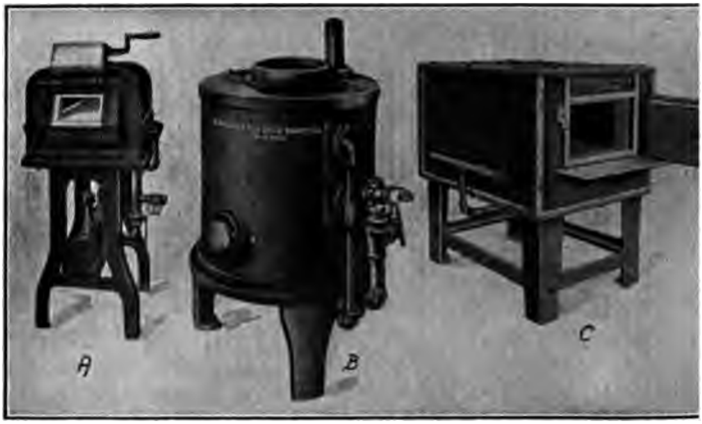


Fig. 459.—Examples of Heat Treating Furnaces. A—Hardenin nace. B—Lead Pot Furnace for Tempering. C—Carburiz Case Hardening Muffle

work is not so uniform as by the treatment previously de In one of these, the metal to be treated is heated in a forge nace until a uniform red, and then placed on a piece of b an iron box, the wood resting upon a bed of ashes several deep. A second piece of board is placed on the pieces, whole covered with ashes. The pieces of wood will smoul maintain the metal at a high temperature for some time. common method of annealing is to heat the pieces to a red h merely bury them in ashes, which is apt to give unsatisfac sults unless the ashes are also heated which can be easily

hed by burying a large piece of heated iron in the annealing . When the steel has been sufficiently raised in temperature this :e of iron is removed and the steel part buried in its place. whole secret of successful annealing is to gradually heat and . the metal to be treated; and the more gradually and uniformly temperature rises and falls, the better the character of the k.

Hardening.—After the parts have been machined to the finished ıearly finished size, approved practice is further heat treatment :ither toughen or harden the steel. The amount and character treatment depend largely upon the use for which the piece is :nded and the composition of the material. Steel may be hard- d by several processes, the most common of which is raising it ι low red heat or dull cherry red and plunging it in some cool- medium such as water, brine or oil, or by case hardening, which ıely acts on the surface of the metal.

Steel should never be heated to a temperature greater than re- red to give the desired result, and the degree varies with the com- ition of the steel as relates to the carbon content, the size and pe of the piece and the purpose for which it is to be used. Much ɪends upon heating uniformly; the edges and corners should be hotter than the center and the interior should be of the same ιperature as the surface. If this precaution is not taken the tal may crack in the cooling bath, because uneven changes take ce in the molecular structure. If heated in an ordinary forge sure that no air from the blast strikes it, which will prevent uni- n heating. When uniformly heated it should be plunged in a h to give it proper hardness. It must be worked up and down idly in the bath to prevent the film of steam forming, which ıld surround it if kept in one position and prevent proper con- ; with the cooling fluid. If the piece is long and slender it must noved up and down, but if short and with teeth on the outer e, as a milling machine cutter it should be agitated rapidly that teeth will be cooled uniformly. If it is flat and has a hole ɪugh it, the walls of which must be hard, it should be so moved ; the liquid of the bath passes through the aperture and at the ıe time strikes both faces. Tool steel should always be hardened

at a temperature (about 1350 to 1450 degrees) which leave grain when the piece is broken, which can be determined b ening and breaking a small piece from the same bar as t is to be made. A coarse grain denotes a higher temperatu is permissible. An excellent bath for hardening small p made by dissolving one pound of citric acid crystals in on of water. The container should be tightly closed when no to prevent loss by evaporation.

HEAT DETERMINATION BY COLOR

Degrees F.	Degrees C.	Color of Heats	
752	400	Red-visible in the dark.	Ter
885	474	Red-visible in twilight.	
975	525	Red-visible in daylight.	
1077	581	Red-visible in sunlight.	Ann
1292	700	Dark red.	
1472	800	Dull cherry red.	Hardening.
1652	900	Cherry red.	Carbonizi
1832	1000	Bright cherry red.	
2012	1100	Orange red.	Forging.
2192	1200	Orange yellow.	
2372	1300	Yellow white.	
2552	1400	White-welding.	
2732	1500	Brilliant white.	

Pack Hardening.—Pack hardening is the method e with pieces that cannot be treated by the ordinary process out risk of springing or cracking them. The article is pa an iron box with some carbonaceous material and subjecte action of heat to cause it to absorb enough carbon to enable ing in an oil bath. While this treatment is not generally u suitable for a number of different tools, such as milling cut taps or dies which must be hardened without altering the c or pitch. The usual material employed is charred leathe is mixed with an equal quantity of wood charcoal, both n being reduced to particles about the size of a pea, or small pieces are placed in a container and packed in the manne box annealing, and as is the case with that process it is just to treat a number of pieces as it is one, providing the box be

nt capacity. The pieces should be wired with ordinary iron re of sufficient size to sustain the weight of the piece when ited, and one end of the wire should be covered with a luting fire clay. Several holes should be drilled in the cover for test es.

The box is placed in the furnace and heated sufficiently (about 0 to 1700 degrees) to charge the parts with carbon, which varies h the character of the parts treated. For instance with a piece one-half inch diameter or under the heat is maintained for about and one-half hours, while pieces from two to three inches in meter must be heated for two and one-half to four hours after parts have become red hot. When the box has been maintained the required temperature for the correct period, it is removed m the furnace and the cover taken off. The parts are then re-ved by means of wires attached to them and immersed in a bath raw linseed oil. They should be moved about in the liquid il the red has disappeared and are then lowered to the bottom l allowed to remain immersed until cold. When a piece of steel inch in diameter or larger is hardened, it should be immedi-ly reheated over a fire after cooling, to prevent cracking, which uld be caused by molecular changes which take place after the er surface is hardened and unable to yield to unequal strains. heating the surface to a temperature of about 212 to 300 degrees hrenheit will accomplish the desired result without materially tening the steel.

Tempering.—The hardening of a cutting tool makes it too ttle to stand up well in use, and consequently it is necessary to ten it somewhat. This operation is known as drawing the per and is accomplished after the part has been quenched by eating to a proper temperature, which is ordinarily determined the color on the surface of the tool, which must be brightened vious to this operation. As the metal is raised in temperature ght, delicate straw color will appear, and then in order, as deep w, light brown, darker brown, light purple, dark purple, dark e, light blue, blue tinged with green and black. When black ears the temper is gone. These colors furnish a guide to the perature and condition of the hardened steel. A table pre-

HEAT TREATMENT OF HIGH-SPEED STEEL TOOLS

Kind of Steel	Method of cutting off unannealed bars	Forging Heat	Hardening heat, Cooling medium, temper and grinding: Lathe and Planer Tools, etc.: Temperature	Lathe and Planer Tools, etc.: Cooling medium	Lathe and Planer Tools, etc.: Condition of wheel used for grinding	Taps, Milling Cutters, etc.: Temperature	Taps, Milling Cutters, etc.: Cooling medium	Taps, Milling Cutters, etc.: Temper required	Directions for Annealing: Packing and packing material	Time required for heating	Temperature required	Manner of Cooling
Burgess No. 4 and No. 5	Cut off hot	Even cherry red	White welding heat on point	Cold air blast or fish oil †	Dry wheel (grind slowly)				3 parts sand 1 part lime	2 to 3 hours	Bright red	Very slowly
Ark	Cut off hot	Canary color	Fusing heat on point	Cold air blast or thin oil †	Very wet wheel	Light yellow heat	Oil †					
Midvale Special Self-hardening	Nick on wheel, Break cold	Dull orange	White heat	Cold air blast		Dark cherry heat; then heat in white hot lead	Oil, cool until color disappears		1 part lime 1 part charcoal		Light cherry red	Slowly
Capital High-speed		Full bright red	White heat	Cold air blast	Wet sandstone	Full white heat	Cold air blast	No temper	Heat in air-tight box lined with fire-brick	1 to 4 hours	1650° F	Very slowly
Heller's Alloy High-speed		Bright yellow	Bright yellow heat	Air blast or fish oil †	Wet stone	Bright yellow heat *	Air blast †	Temper seldom required	Powdered charcoal. Air-tight box		Bright yellow (2000° F)	Slowly
Blue Chip		Cherry red	Clear white heat on point	Air Blast or oil	Dry wheel	White heat just below fusing	Oil	Straw color	Lime Air-tight box		Bright red or dark yellow	Very slowly
Allen's Air Hardening		Bright red	White heat on point	Cold air blast or water at 180° F.	Wet stone				Lime Air-tight box		Bright red	Very slowly
Bethlehem Self-hardening	Cut off hot	Between bright cherry red and full yellow	White heat on point	Dry, cold air blast		As hot as possible without fusing	Oil		Heat and bury in lime		Bright cherry red	Slowly
Rex High-speed	Cut off hot	Bright red	Fusing heat on point	Cold air blast (cool until tool can be held in the hand) †	Wet or dry	As hot as possible without fusing	Oil †	Temper if necessary	Charcoal, lime, or sand, air-tight box	2 to 8 hours	Full red	Very slowly
Novo	Cut off hot	High lemon color	Fusing heat on point	Cold air blast or running lard or fish oil †	Wet wheel (grind slowly)	Red heat; then white heat in furnace	Thin fish or cotton seed oil †	According to use of tool	Lime in air-tight box	12 to 18 hours soaking heat	Full red	Very slowly
Bohler's Styrian High-speed	Nick hot, break cold	Bright yellow	White heat, (not fusing)	Cold air blast		White heat, just below fusing	Fish oil		Charcoal Air-tight box	4 to 6 hours	1830° F.	Slowly
Mc. Innes extra High-speed		Full red	Fusing heat on point	Air blast or fish oil	Dry stone	Light cherry red heat	Air blast or fish oil		Ashes or lime, air-tight box		Cherry red	Slowly

Note: If common forge is used for heating, have a deep fire, plenty of coke and light blast. In general, oil, gas, or coke furnace is preferred. * Do not use gas fire. † While steel is hot, it must not be dipped in water.

Contributed by [illegible], Machinery's Data Sheet No. [illegible]

:ed herewith gives the color and corresponding temperature at ch the various tools mentioned are best quenched. When work ɜmpered in large quantities the above method is expensive, and .ot as reliable as when the articles are heated in a kettle of oil, ıg a thermometer for indicating the temperature. A piece of forated metal is used to keep pieces away from the bottom of kettle, though a wire basket will serve the purpose even better. soon as the parts are raised to the required temperature they quenched to harden.

Case Hardening.—When an article of wrought iron or low bon steel is to have a hard surface it is not possible to treat it merely quenching, as there is not enough carbon in the steel to ure proper hardening. The process of treating such materials known as case hardening and consists of covering the surface ile red hot with some material which forms a coating or case l, which can be hardened by quenching, as in previous processes. ıll parts, such as nuts, bolts, cones, etc., may be case hardened heating red hot and covering with a thin layer of powdered ıide of potassium, and when this melts, the article is again ;ed to a red heat and plunged in water. While the above pro- is suitable for hardening a few small pieces it is not recom- ded for large quantities of work, as the results would not be uni- n and the process would be too expensive. If many small pieces to be case hardened at the same time, they may be treated in h the same manner as in box annealing. Granulated raw bone, granulated charcoal should be mixed in equal proportions and ıyer of this mixture placed in an iron hardening box to the depth one or one and one-half inches. A layer of the articles to be ıted is then placed in this and these are covered with more ma- al, the same care being observed in packing and with regard to pieces as with other processes. After the container has been ed it is placed in a hardening furnace and the temperature ntained at a point which will keep the pieces at a red heat for iods varying with the degree of the surface hardening desired. .erally carbon will penetrate the surface of wrought iron or soft l one-eighth inch in 24 hours, but as it is seldom necessary to den any deeper than one-thirty-second inch, the work may be

taken out after four or five hours. With small pieces the cor may be emptied into a tank through which there is a constant lation of water. If great toughness is required, the packin terial is sifted out and the pieces immersed in oil. Large must be dipped one at a time and can be wired so that the be removed from the hardening box when desired. There has great development of late in scientific heat treatment, though not within the province of this treatise to discuss these in the processes which have been described being those which particular interest to the practical mechanic or repairman.

Distinguishing Steel From Iron.—While nitric acid has fect upon the brightness of iron, it will produce a black sp steel, and the darker the spot the harder the steel. Good steel, in the soft state, has a curved fracture and a uniform gray but in the hard state it is a dull silvery uniform white. Crac threads denote inferior quality. Good steel will not bear a heat without falling to pieces, and will crumble under the ha at a bright heat, while at a mild red heat it may be drawn a point. Iron cannot be hardened as its carbon content i low.

Hardening Steel Tools.—One of the best, if not the best, positions for hardening steel tools for cutting iron or wood, or steel, is the following: To one gallon of common fish or wha add one pound each of beeswax and resin. When this has thoroughly mixed by boiling and stirring, heat the steel unti scale rises a little; then immerse in the boiling oil. When cool, over a clean fire until cherry red, and immerse in cool oil. hardens steel, whereas beeswax and tallow toughen it. If preferred to temper in daylight, clean the steel, polish it, and to the color desired.

Temperatures for Tempering.—The following table give required temperature in Fahrenheit degrees to produce ce colors, when tempering hardened steel:

Lathe, shaper and planer tools:

430. Very light straw.
450. Light straw.

Taps, dies and wood turning tools:

470. Dark straw.
490. Very dark straw.

Ratchets, chisels, etc.:

500. Brownish yellow.
520. Yellow, tinged with purple.
530. Light purple.

Springs, etc.:

550. Dark purple.
570. Dark blue.

Molten Metals Produce Desired Heat.—The following table gives the proportional parts of lead to one pound of tin, which when melted will have the required temperature to produce certain colors on hardened steel, by simple immersion:

TEMPERATURE

Color	F. Degrees	Proportions
Very light straw	430	1¾ to 1
Light straw	450	2⅛ to 1
Dark straw	470	2½ to 1
Very dark straw	490	3½ to 1
Brownish yellow	500	4¾ to 1
Light purple	530	7½ to 1
Dark purple	550	12 to 1
Dark blue	570	25 to 1

Working Steel and Iron.—Steel never should be kept hot longer than necessary for the work to be done, as if left too long in the fire it will lose its steely nature and grain, assuming more of the qualities of cast iron. When steel has been subjected to heat not absolutely uniform over the whole mass careful annealing should follow. Hot steel always should be put in a perfectly dry place of even temperature while cooling. A wet floor might prove sufficient to cause serious change. It is hard to make the average worker in steel believe that very little annealing is necessary,

and that a very slight change is more efficacious than a gr
Iron heated and suddenly cooled in water is hardened
extent and the breaking strain, if gradually applied, is ir
but it is more likely to snap suddenly. If heated and
to cool gradually it is softened and its breaking strain is
If brought to a white heat iron is injured if it is not at t

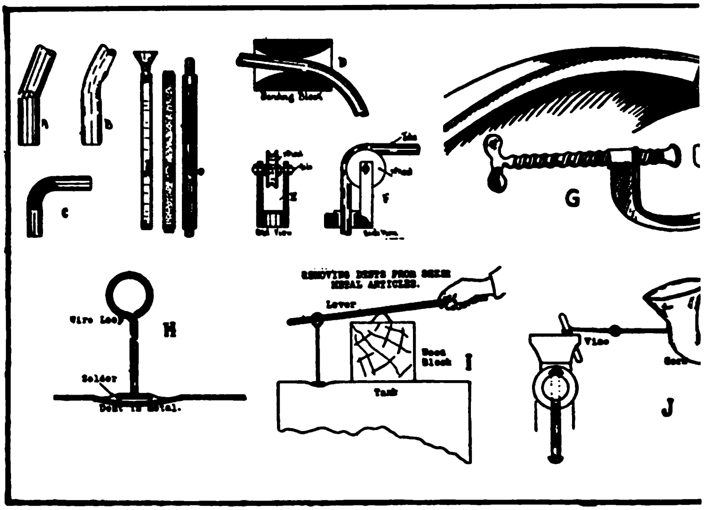


Fig. 460.—How to Remove Dents from Sheet Metal Objects a Methods of Bending Steel Tubing and Pipe.

time hammered and rolled. Case hardening bolts weaker
to some extent.

Annealing Cast Iron.—To anneal cast iron heat it in
charcoal fire to a dull red, cover it with about two inches
charcoal and spread over all a layer of ashes. It should
until cold. Hard or chilled cast iron can be softened sufi
in this manner to be filed or drilled.

Bending Pipe and Tubing.—Tubing is widely used in t
struction of the automobile and its parts, and the repairm
sometimes desire to make a bend to replace a defective com
such as a water or gas inlet or exhaust pipe, which has

:ed and dented. Tubing is made of many materials, copper, and steel being the most common. It may be either hard or iled, depending upon the use for which it is intended. The .l or temper of seamless tubing is very important and should :efully considered before bending. All seamless tubes, regard- f the metal of which they are made, after being cold drawn ery hard and inclined to be brittle, and have to be annealed t different requirements. Tubing is furnished in three differ- :mpers—hard, medium and soft. The hard tempered is used : great strength, rigidity and stiffness are required and where ibes are not to be manipulated in any way that would change form. The medium temper is used where strength and tough- ire needed and where only slight or medium change of form uired. The soft is used where the tubes must be manipulated here such decided change of form is required that it demands :e and pliable material.

man not a mechanical expert is not expected to know the ent grades of tubing, and in procuring this product the mis- is often made of buying tubing which is not suitable. A file ell the mechanic of the degree of hardness and proper allow- are made when it is desired to make bends. Many tubes of ent make are finished so nearly alike that it is difficult to nine just what will be the most suitable. The thinner the wall : tube the more care will be necessary to make a good bend as valled tubing is more liable to collapse than that with thicker

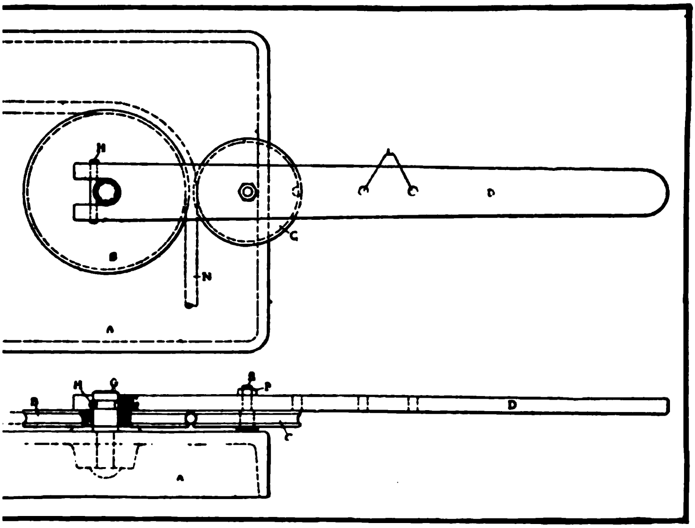
If a piece of hard tubing is bent without first annealing, l break soft, as at A, Fig. 460. A piece of thin-walled tubing :ollapse as at B. Some tube with a moderately thick wall e bent without heating or filling though most now used in the hould be filled before bending. If the interior is made solid arly so with some substance it can be bent to a curve of very radius without damage to the wall, providing the tubing is :rly heated and is of the right temper. Such a bend is shown

With a solid filling it is possible to manipulate the tube as :d, but it is not a good idea to use either a vise or wrench, or ier and anvil for bending as the walls of the tube will suffer he appearance of the joint be unsatisfactory at least.

Filling the Tubing.—In securing a good bend special care i be taken of the material or filling to be used as a support foı inner wall while bending. One way of filling or packing a pip tube for bending consists of pouring into the internal bore a mc substance, such as resin for brass and copper pipes, or a soft, melting point lead alloy in steel tubing. The thinner the wall more carefully must the bending be done, and the heavier material used for a core. The method of filling is very sim a funnel is inserted in the tube and the molten material poure and allowed to cool. This may be removed after the bend is m by heating the tube, which causes the substance to melt and it ı be run out. A tube may be packed with clay or putty, tho these substances are hard to remove from the interior after bend is made. For hot bending the tube may be plugged up packed with sand, which is easily removed. If the entire len of the tube is to be bent around the arc of a circle the core maj a soft iron rod, which can be removed with ease after the opera is complete as it has taken the same degree of curvature as the t This also permits of hot bending. The tube is inserted in the of a bending block or when in a fixture may be bent back over wheel, and curves of any radius may be obtained by using la or smaller wheels. The device is often made so that it ca clamped in a vise, though where much work of this charact done it is fastened securely to the bench. For the motorist makes his own repairs or the experimenter the block shown is cient, as good work may be done with even such a simple appl if proper care is taken in filling the tube before bending.

The pipe bending fixture shown at Fig. 461 was illustrat the Horseless Age and is a very simple one to build, requiring materials and tools found in almost all garages for its fabric With this device it is not absolutely necessary to fill the pipe sand, resin or other material. The description will enable c make such an apparatus. At A is shown a cast iron base two feet square and two inches wide, cored out underneath to make it lighter. At B is a grooved wheel which is rem so that it may be replaced with similar wheels of different dia for different sized bends. For instance, if the pipe is to be b

radius, a wheel 8 inches in diameter will be required. The ıs a groove turned in its outer edge just a trifle larger than to be bent. It is made so that it will slip off and on the easily. This stud is made of steel and is riveted to the as shown. A follower wheel C is attached to the handle D is used for any bend for a given size of pipe. It will be



461.—Simple Fixture for Bending Tubing Without Damaging the Walls.

that the lever D has a series of holes, these being so spaced ən a different sized wheel replaces B, the wheel C can be ut toward the end of the lever, keeping the center of the etween the two grooves. The wheel C is held in place by a stud E and locked with a nut F. Since the base A has finished off for the larger wheel to turn upon, the head of E will clear the base when the lever arm is swung around. 1 G has a shoulder or groove cut around it, as shown in onal view. This is done to allow a tapered pin H to lock D in place. The lever is milled out at the end, as shown

in the plan view, and a hole is drilled through both sides to take the tapered pin, which is placed so that it will lock the lever on the stud and yet allow it to turn freely. At J is shown a block machined out of rectangular stock with a round end turned on it so that it may be inserted in the base, A. A hole is drilled in the piece just a trifle larger than the pipe and a slot sawed through the hole. Then another hole is drilled at the top for a clamping bolt K to hold the pipe in place. The apparatus is now ready for use.

To bend a pipe of the size for which the block J and the wheels B and C have been made, turn the lever back 90 degrees from the position shown in the illustration. Then insert the pipe between the grooved wheels and clamp the end in the block J. Then pull the lever around to the position shown for a 90-degree bend and another 90 degrees for a return bend. The holes for the stud J are drilled in the base A on a line with the centers of the two grooved wheels, and these holes can be drilled in all four sides of the base. It is best, of course, to set up the apparatus and bend all of one size pipe and one radius at one time. After making a bend, the pin H is removed, which allows the lever to be pulled forward, carrying with it the wheel C. This leaves the pipe free to be removed after being unclamped from the block J. Sometimes a piece of pipe is encountered which is so hard that it cannot be bent easily. In this case the lever may be lengthened by slipping a length of gas pipe or other tubing over the outer end giving a much greater leverage and particularly stubborn pieces of pipe or tube may be bent by heating several times if necessary.

Straightening Out Bent Fenders.—When the fenders become bent the usual practice is to remove them and take them to a tinsmith for repairs. This involves considerable trouble and delay. The average fender may be straightened out by taking a block of wood or a strip of metal and placing it on the damaged part as outlined at Fig. 460, G. A clamp is then attached and when screwed up the kink in the metal will be eliminated. While some of the paint will crack, the fender will present a much better appearance than if it were straightened by hammering.

Removing Dents in Tanks, Etc.—The following methods of taking out dents in hollow metal containers may prove of service

ɜpairmen as well as motorists in general. If the side of the tank, for example, is indented, a loop can be made in a piece ;out brass wire, or a piece of bright steel rod, which is bent at t angles and soldered to the lowest part of the dented metal, t H, Fig. 460. A larger loop is then made in the other end of wire and with the aid of a small pinch bar and a block of wood ct as a fulcrum for the lever, the dented surface can be easily ed flush with the surface of the tank. The base of the wooden :k should be of sufficient area to prevent the side of the container)ming indented by it because of the pressure brought to bear a the lever or bar. Dents in headlights and depressions in the faces of horns, small tanks, gas generators, etc., can be taken in a similar manner except that in place of the bar a stout d should be attached to the wire loop and its free end fastened a vise or other convenient anchorage. Fig. 460, I, shows method repairing a tank, while J shows a sketch of a horn under treatnt. The latter is grasped in the hands and a few gentle pulls l remove the dent. Obviously any other small metallic article ι be repaired in the same way. The wire loop in all instances ι be easily applied or removed with a blow torch or soldering a.

No doubt more elaborate methods can be resorted to by those lled in sheet metal working, but the writer believes that the ɪve method is as simple as any for a piece of wire can be easily ιt to any shape to suit the requirements of the job under conɜration. No tools of great value are necessary, and such as are d—viz.: a length of wire and soldering iron—can be found in ιost any house, and the process presented can be used to adιtage with any gauge of metal generally employed in the conıction of the various small articles which the motorist would ɜmpt to repair himself.

Soldering and Brazing Processes.—Solder must be used on cera parts of an automobile, notably the radiator, the tanks and the ıps, despite the fact that such construction when subjected to ess or vibration, is not considered best. It is of considerable imrtance that permanent work be accomplished and in reaching s result it is necessary to bear in mind certain fundamental prin-

ciples relative to the use of solder in all classes of work. metal surfaces to be joined must be clean. This means in rigid sense. Wiping or cleaning with acid or gasoline is cient. The metal must be clean, chemically, as well as i any oxide. The best method is to use sandpaper or file th just before soldering. The surfaces must be hot—as w solder itself. The solder must be melted to flow with pe

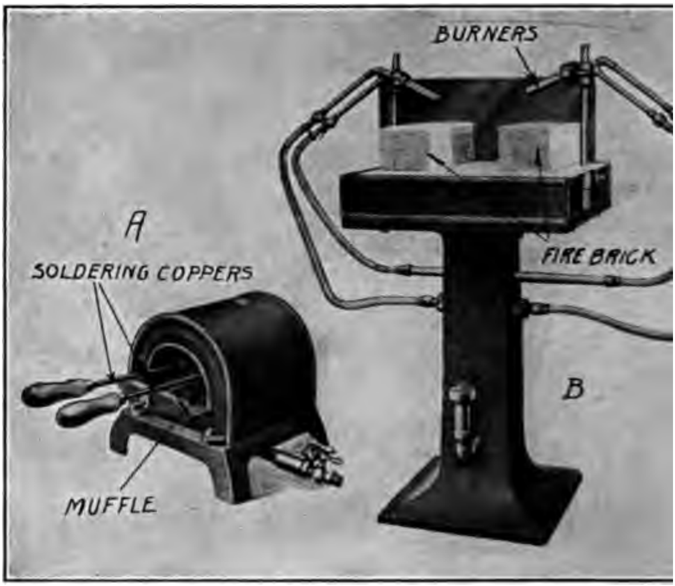


Fig. 462.—Furnace Used for Heating Soldering Coppers at Efficient Brazing Forge at B.

dom, otherwise it will not enter the pores of the surf joined. The solder must not be so hot it will burn, ho solder bath or a soldering iron never should get red hot. difficult to do a good job if the iron is large enough. .

Time must be allowed for the heat to flow from the the work. To prevent the solder running away the work held with the seam horizontal. It is impossible to hurr this kind, except by changing irons to keep the work

hes are due either to imperfect cleaning or to the working be- hurried through before it has been heated properly. The ıgth of solder is small, and its elastic limit far below its ten- strength. The area of the joint must be large. Two strips lapping by a narrow margin are not as strong as with a wide rlap. With a lap sufficiently wide it is quite possible to make a ıt stronger than any other part of the piece, not forgetting, how- r that a soldered joint never should be subjected to bending or er stresses which localize the strain endured by the solder. The ice of flux naturally will depend upon the work. The object he flux is to preserve the chemical cleanliness of the metal while being heated and before the solder adheres. Save for the flux hot metal would oxidize slightly on the surface and the solder ld not unite with it.

[f it is desired to solder two pieces which have some thickness bulk a good piece of work cannot be done with a soldering iron, use the parts will absorb heat faster than the iron can supply With such work a torch must be used for sweating, heating oughly the parts adjacent to the intended joint and as far back aay be necessary. If the surfaces are more than one-eighth to quarter inch wide it is better to tin them before uniting. This one by spreading a smooth coat of solder over the entire sur- while hot. It is only necessary to press two such prepared es together and heat them to the proper temperature to make erfect union. Much time is saved in sweating operations, par- ılarly in manufacturing, by dipping the work into a bath of lten solder. The hot solder supplies the necessary heat and the le job is practically instantaneous. Great care is necessary to p the bath at proper temperature. If it is too cold the work will hold, and if it is too hot the solder will be burned and its use- ıess gone. The accompanying tables will be found useful, one ng the fluxes that are best used with various materials, while other gives the composition of solders and spelters found sat- ctory for general application. The more tin there is in a solder, stronger it is, but it is harder to melt than those having lead as redominating element. In the case of spelter increasing the portion of copper increases the strength:

Fluxes for Soldering.

Iron or steel ....Borax or sal-ammoniac
Tinned iron ....Resin or chloride of zinc
Copper to iron ....Resin
Iron or zinc ....Chloride of zinc
Galvanized iron ....Mutton tallow or resin
Copper or brass ....Sal-ammoniac or chloride of zinc
Lead ....Mutton tallow
Block tin ....Resin or sweet oil

SOLDERS AND SPELTER FOR DIFFERENT PURPOSES

Solder for	Silver	Tin	Lead	Zinc	Copper	Gold	Brass
Electricians................	.	1	1	.	.	.	.
Gold........................	2	.	.	.	1	24	.
Platinum....................	3	.	.	.	1	.	.
Plumbers', hard.............	.	2	1	.	.	.	.
Plumbers', soft.............	.	1	3	.	.	.	.
Silver, hard................	4	.	.	.	1	.	.
Silver, soft................	2	.	.	.	.	.	1
Tin, hard...................	.	2	1	.	.	.	.
Tin, soft...................	.	1	1	.	.	.	.
Spelter for fine brass......	1	.	.	8	8	.	.
Common brass................	.	.	.	1	1	.	.
Cast iron...................	.	.	.	3	4	.	.
Steel.......................	.	.	.	1	3	.	.
Wrought iron................	.	.	.	1	2	.	.
Parts by weight.............							

Lead Burning.—Lead burning consists in melting the metals and causing the parts to flow together and become joined without the aid of solder. It requires considerably more skill than any other form of brazing or soldering. A long step toward success may be taken by the proper arrangement of the work. It is usual to provide something which may serve as a mold or guide for the melted metal. For example, if two lead sheets are to be united by soldering, they are laid on a sheet of some non-heat-conducting substance, such as brick or asbestos. The work in the immediate neighborhood of the joint is carefully scraped so as to remove all oxide or scale which would tend to bind the melted lead and pre-

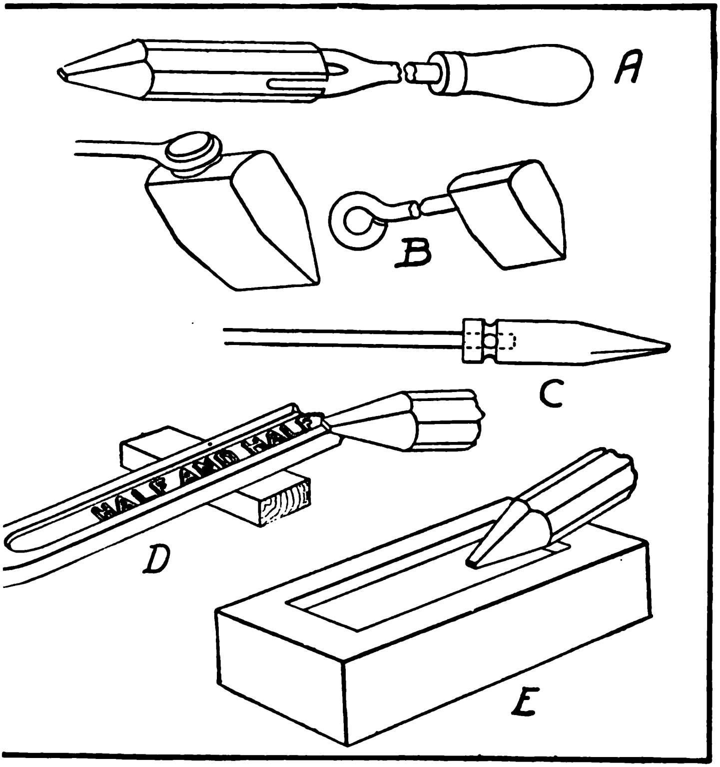


Fig. 463.—Forms of Soldering Coppers and How to Tin Them.

t from flowing freely. The metal at the seam is heated by
r hot bit or the flame from a blowpipe so that there is a uni-
flow of lead across the seam. It is sometimes necessary to
ıore lead to the seam by melting a strip held in the hand.
ne of some sort is the most satisfactory source of heat for the
ge lead burning job, because not only is the heat more uni-
but also more intense, and the lead melts at the desired point
the surrounding metal becomes sufficiently hot to soften.
are several types of blowpipe for this purpose on the market.
employ an alcohol flame, while others make use of mixed
gen and air. The flame is usually small, sharp-pointed, and

very intense. Lead burning is absolutely necessary, and is insi upon in certain classes of work for instance, in lining tanks lead for chemical solutions, or for joining the grids and lug storage batteries.

Soldering Aluminum.—Many components of the modern m car are made of aluminum and in making repairs, if these be bro or cracked, this metal is extremely difficult to solder. While m attempts have been made to solder aluminum in the ordinary w and even with special fluxes and solders, but little success is tained unless the conditions obtaining are fully appreciated. minum is very light and melts at comparatively low temperatu and because of its rapid oxidization it is necessary to take great c to secure bright metal to which the solder will adhere. The all with which the motorist has to deal vary in proportion of alloy elements, depending upon the use for which the metal is inten the substance commonly used in combination being zinc, copp tin, manganese, magnesium and sometimes a trace of iron. larger proportion of any alloy is aluminum, and on the whole soldering problem will be about the same in all cases. As must obvious because of its low melting point, aluminum will not st prolonged heating, a condition that may be disregarded in the of most of the other metals amenable to soldering and brazing p cesses. Then again, when the critical point is reached in the h ing, aluminum suddenly "wilts" and every precaution must be served to prevent the metal becoming too hot. The following t will show the relative melting points of the common metals:

Melting Point of Metal.

	Degrees Fahrenheit
Tin	445
Lead	620
Zinc	780
Aluminum	1160
Bronze	1690
Silver	1730
Gold	1900
Copper	1930

Melting Point of Metal.—Continued.

	Degrees Fahrenheit
Cast iron	2000
Steel	2400
Wrought iron	3000
Platinum	3230

From the foregoing it will be evident that the metals of which e average solders are composed have melting points but little wer than that of aluminum, and careful manipulation will be cessary to insure heating the metal sufficiently to melt the lder, and at the same time not weaken the aluminum or cause it flow. To successfully solder aluminum demands considerable eparation and careful manipulation, and authorities differ as to e best methods and solders to use. All agree that the metal must dry and absolutely clean, and while this is easily said and ad-sed it is difficult of accomplishment. If one cleans aluminum ordinary temperatures, no matter how carefully, and obtains a ight surface, it is impossible to retain this as new oxide forms its surface as soon as brightened. For this reason, some skilled the arts recommend immersing the parts to be soldered in a rong solution of hydrosulphate of soda for several hours before oining them. The best solder to be used depends to a certain ex-ent upon the alloy of aluminum, the same as with other metals. ne that has been used with good success is made as follows: Ten arts each by weight of tin, cadmium and zinc and one part of lead ll of which are melted together.

Dampness or salt air are the bane of the process of aluminum oldering and the rapid oxidization makes "tinning" which is of uch benefit in uniting other metals, practically impossible. As oisture will hasten oxidization, the safest method of proceeding ill include the drying of the surfaces, assuming that these have een properly prepared, as well as the solder, in an oven or other itable container at a high enough temperature to thoroughly heat ll parts, but lower than that required to melt the solder. When e parts are thoroughly dry, the next thing to do is to scratch e surfaces vigorously with a metal brush, bringing out the un-

tarnished metal, and removing all traces of oxide. The next step is the heating of the aluminum parts nearly to the melting point of the solder, and after applying the alloy to the surfaces, brush it into intimate relation with the surfaces, using the metal brush. If the solder does not adhere there is still some oxide on the surface, and the operation of cleaning should be repeated. When the surfaces to be joined are properly coated with solder, the rules which govern ordinary soldering work will apply, it being merely necessary to heat the surfaces, melt the solder and join the surfaces. Either a bunsen burner or blow torch can be used to heat the metal and the important points to remember are that the work must be done quickly and that the surfaces to be joined be as clean and dry as possible, and as free from aluminum oxide as conditions will permit.

If the surface is of such a shape that it cannot be readily cleaned by scraping, it can be cleaned by dipping it into a solution of nitric acid in three times its bulk of hot water containing about 5 per cent. of commercial hydrofluoric acid. This causes a slight action on the surface of the metal as shown by bubbles. Rinse the metal after removing from the acid bath and dry in hot sawdust. There are various compounds on the market for soldering aluminum, but this operation depends more on the workman than on the solder and unless considerable experience has been had it is probably better to purchase solder than attempt making it. Zinc can be used but does not form a very strong joint. Tin can also be used, is more nearly the color of aluminum, is stronger than zinc, but is very difficult to work. A small proportion of phosphor tin added to pure tin makes it work more readily and is the basis of most aluminum solders. The chief difficulty in soldering aluminum is that the heat is dissipated so rapidly that it cools the soldering iron and furthermore aluminum oxidizes instantly upon exposure to the air. This extremely thin film effectually prevents a perfect union being made. If the parts are well heated and melted solder kept hot while the iron is allowed to stand on it, the surface can be scraped beneath the melted solder by the point of the soldering iron, thus preventing to a certain extent the oxidization. In this way the metal can be tinned. When both parts are brought to

:r and are well tinned, they can be united with some chance iccess, nitrate of silver, resin, or zinc chloride being used as x. A soldering tool of nickel gives more satisfactory results a copper one as the latter alloys with the tin and soon be- s rough.

nother authority advises as follows: Use zinc and Venetian :ntine for soldering small surfaces. Place the solder on the l and heat very gently with a blowpipe until entirely melted. her is to clean the surfaces by scraping and covering with a of paraffine wax as a flux then coating the surfaces by fusion, : a layer of alloy of zinc, tin and lead, preferably in the fol- ig proportions: Zinc, five parts; tin, two parts; and lead one Metallic surfaces thus prepared can be soldered by means nc or cadmium, or alloys of aluminum with these metals. ity-eight ounces of block tin, three and one-half ounces of lead, . ounces of spelter, and fourteen ounces of phosphor tin, con- ıg 10 per cent. of phosphorus, will make a good aluminum r. Clean off all dirt and grease with benzine, apply the solder a copper bit, and when the molten solder covers the metal, :h through the solder with a wire scratch brush. A good solder ›w grade work is composed of tin, 95 parts, and bismuth, five . A good flux in all cases is either stearin, vaseline, paraffine, va balsam or benzine. Small tools made of aluminum or nickel d be used in the operation of soldering. These facilitate at ame time the fusion of the solder and its adhesion to the ously prepared surfaces. Copper or brass tools should be .ed as they would form colored alloys with the aluminum and older. To sweat aluminum to other metals, first coat the alu- m surface with a layer of zinc, on top of which is melted a of alloy of one part aluminum to two and one-half parts of The surfaces are then placed together and heated until the between them is liquefied.

:ow to Braze Steel and Iron.—As with soldering, it is impor- in brazing to clean the work thoroughly. Sand blasting is leal method of cleaning for brazing, although the work may ›ne with a file and emery cloth. The sand blast not only cleans ıetal of all scale, but penetrates the pores, leaving it in condi-

tion to receive and hold the brass. It also costs less than the method. There are several compounds in the market that will a better flux than borax, burnt and ground fine, but if wante a quick job, mix borax with wood alcohol, or, better still, "C bian Spirits." Clean water is nearly as good. Mix to a thin and apply with a thin brush, so as to wet thoroughly every of the joint. The flux is held in place by painting the joint w mixture of machine oil and black lead. The joint should be p to hold it in place while being brazed. Run a No. 29 drill th the job and hold in place with an eightpenny wire nail. Th should be clean, whether of gas, coal or oil. The gas fire is though it costs more. Put the heat on the heavy part of the first, so as to bring it up nearly to the brazing point. Whe heat is put onto the joint the heavy part will absorb it and c the part to be brazed. Bring it up slowly to a bright yellow and as the spelter and flux begin to melt, dip the brazing w the brazing compound and apply to the joint. Before dippi wire, however, it should be held in the flame so as to heat it a as possible to the melting point and yet not melt it. As th and spelter melt turn the work so it will run to all parts joint, and while still turning remove it from the fire and kee motion until it sets. If it is a large job, turn off the heat a the blast strike the work and cool it.

Nothing equals the sand blast for cleaning work afte finished. The next best method is pickling in a weak solut sulphuric acid and water, about one quart of acid to a ba water. The old-fashioned method of dipping the work in of soapsuds is not recommended. Almost any broken joint iron can be brazed, and if properly done it will be stronger tl fore breaking. To make a good job first heat the work to red, taking the dirt and grease out of the pores of the metal. clean the work with a sand blast or with a wire brush, after apply the flux. Fasten the broken parts firmly together, p the fire and bring up to a bright yellow heat, in fact almost melting point, and apply the brazing compound. Shut off and allow it to cool without moving. Brazing is possible the pieces are of irregular form though large work should

ed before brazing as described in speaking of the autogenous ling process.

Simple Methods of Testing Lubricating Oils.—To find if an ontains certain solid impurities, add kerosene to half a cup of oil until the mixture becomes quite thin. This thin fluid is now sed through filter paper or ordinary colorless blotting paper. soon as all of the thinned oil has passed through, the blotting ilter paper is washed with kerosene. The residue that remains, here is any, will show whether the oil contains any solid imities. Impurities of this kind may also be determined in a se way by smearing a piece of common correspondence or pad er with the suspected oil and holding it against the light. If oil is free from solid impurities the blot of oil will be equally sparent everywhere. If not, the solid particles of sediment will lainly visible.

To test whether an oil becomes resinous or not, it must be poured shallow dish, and it is then to be left for about a week in some n place. If at the end of this period there is not the slightest ence of a crust you may consider the lubricant to be all right. se oils may also be tested by mixing them with nitric acid. If oil is pure, a thick mass will form in a few hours. Oils that iify do not thus clot, but remain very thin.

Among other impurities in oils are to be found injurious acids. n acids occur in lubricating oils they destroy the parts of maes and other apparatus that they lubricate much more quickly should be the case. A test for such impurities is found in ng the lubricating oils with copper oxide or copper ash. These added to the oil in a glass container. When, if the oil is free acid, it retains its original color. If acids are present their n on the copper makes the color greenish or bluish. This test also be made by dropping the oil on a sheet of copper or brass. it should be left for a week, when at the end of that time if is present, a greenish discoloration will be seen on the metal. ost any of the chemical test for acid as with colored solutions litmus paper will indicate the occurrence of acid. Litmus r turns pink in the presence of acid. In its absence a blue will be apparent.

To compare the lubricating values of several oils a few d must be placed on a smooth, slightly inclined metal or glass s The better and the greasier the oil the farther will a drop travel in any given time you determine upon.

Evils of Exhausting in Closed Shop.—With the coming of weather adjustments to motors are often made in the garag testing shop proper, instead of outside, as is the case when we conditions are mild. Many of the garages are insufficiently he and of course all doors and windows are kept closed in ord retain what heat there is present. When such is the case, care be taken that the motors be run very little unless the window doors are opened to provide for ventilation. The exhaust g very poisonous and cases are known where workmen have narr escaped asphyxiation, when running motors continuously in shop and exhausting directly into the room. If it is necessa run a motor continuously and conditions are such that win or doors cannot be opened for ventilation, it will be found able to lead the exhaust gas from the room by attaching a pie heavy rubber hose from the discharge pipe of the muffler to a dow, which need be open but a trifle, to allow the end of the r hose to hang out into the air. Such a simple precaution will many a severe sick headache or something more serious. W the hose goes on the exhaust pipe it must be lined with asbest prevent the heat of the pipe decomposing or burning the Owing to the free flow provided for the gas, the hose will no come unduly heated at other parts.

The exhaust gases from a gasoline engine are composed of n gen, a little free oxygen, hydrocarbon, hydrogen, carbon mon and carbon dioxide, the last two being considered dangerous. presence of carbon dioxide as a product of combustion of the line was recognized as an objection from the beginning of th of these machines, but attention was called to the fact tha amount produced was relatively small compared to other so of this gas, and it was not likely to be made in dangerous q ties. The effect of carbon dioxide, except in relatively larg centages, is confined to reducing the oxygen content of the ai is breathed. The presence of carbon monoxide in the exhaust

ıjurious quantities was less apparent, but it appears from what ›w known that this is the limiting factor in the use of engines :usting into poorly ventilated places. The presence of carbon oxide in the air in relatively small quantities has been shown ıve a marked effect upon the blood, producing sickness, and if led in sufficient quantity, death. After careful inquiry, the that can be stated at this time is that without injury to health, ıore than 0.1% of carbon monoxide can be breathed and that , short and infrequent intervals. It is probable that one-half ıis percentage could be allowed for a considerable period of without noticeable effect. The per cent. of carbon monoxide e garage air depends upon the amount made by the engines ing and on the quantity of air with which it is mixed. It will ɘcessary to provide ventilation for the worst combination of , which such engines can make under unskillful handling, or o become informed as to the actual amount of carbon monoxide uced and provide air accordingly.

t is not sufficient to consider the average amount produced as ibuted over the whole time of running such a machine. The quantity of gasoline burned in any one day may have prod but a small quantity of carbon monoxide, but if this has confined to a relatively short period during bad carburetor stment, and in some poorly ventilated space, the momentary ɜntage may be very high and the consequence may be fatal. It ident that to be entirely safe the ventilation must be sufficient ep the percentage of carbon monoxide below the assigned limit ı the engine is producing the maximum quantity possible. If naximum quantity is provided for by proper ventilation, the ce of injury to health may be considered to be remote. Cerpeculiarities of gasoline engines cause the percentage of carmonoxide generated to vary between rather wide limits, but naximum is fairly constant. No other constituent of the ext gases varies so much or so rapidly with slight changes of adnent as does the carbon monoxide. Conveying the exhaust gas ıe outer air is the simplest and most positive remedy for disl of this deadly gas.

nstructions for Repairing Storage Battery.—In repairing

Willard storage battery a definite routine must be followed in tearing down and building up same in order that it will be in the best condition when re-assembled. These steps are as follows:

First: Remove all vent plugs and washers.

Second: Centerpunch both top connectors in each cell which is to be repaired; then drill ¾-inch into top connector, with a ⅝-inch diameter drill. Now pull off top connector with pair of pliers.

Third: Apply gas flame or blowtorch flame to the top of the battery long enough to soften the sealing compound under the top cover. Now, with heated putty knife, plow out the sealing compound around the edge of top cover.

Fourth: Insert a putty knife, or any other thin, broad pointed tool, heated in flame, along underside of top cover, separating it from the sealing compound. Then with putty knife, pry the top cover up the sides and off of the terminal posts.

Fifth: Then, with heated putty knife, remove all sealing compound from inner cover.

Sixth: Now play the flame onto the inner cover until it becomes soft and pliable; then take hold of both terminal posts of one cell, and remove the elements from the jar, slowly; then lift the inner cover from the terminal posts.

Seventh: Now separate positive and negative elements, by pulling them apart sideways. Destroy old separators.

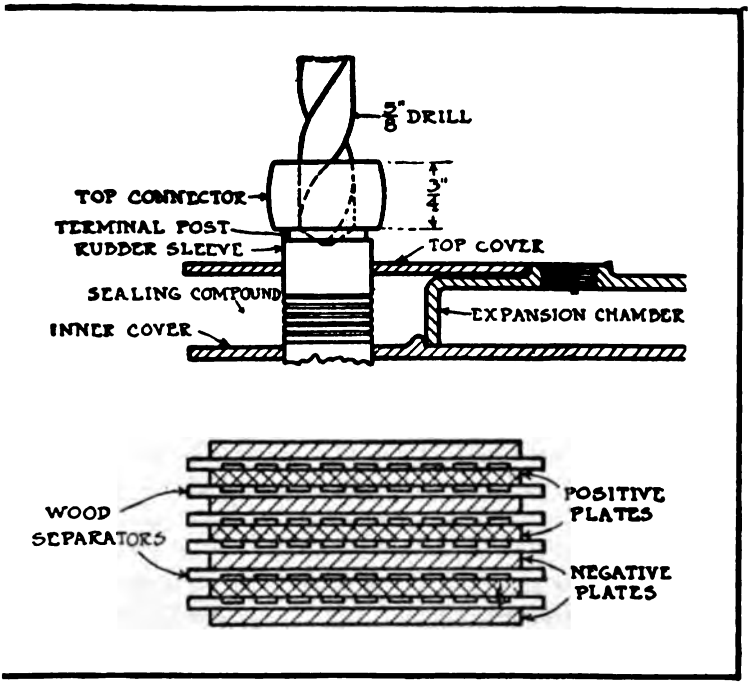
Eighth: To remove a leaky jar, first empty the electrolyte from the jar, and then play the flame on the inside of the jar until the compound surrounding it is soft and plastic; then with the aid of two pairs of pliers, remove it from the crate, slowly, lifting evenly.

Ninth: To put in a new jar, in place of the leaky one, heat it thoroughly, in a pail of hot water, and force in gently.

Tenth: In re-assembling the battery, first assemble the positive and negative elements, pushing them together sideways; then turn them on the side and with both hold downs in place, insert new separators, being very careful to have the grooved side of the separators next to each side of each positive plate. Also be careful to have the separators extend beyond the plates on each side so there will be no chance of the plates short-circuiting. Now press all separators up against hold downs.

Eleventh: Heat up inner cover with flame; then place same on ıinal posts; then take hold of both terminal posts and slowly r the elements into the jar

Twelfth: Now, with expansion chamber in place on the inner r, pour the melted sealing compound on to the inner cover,



;. 464.—Diagram Showing Construction of Points to be Reached in Rebuilding or Tearing Down Willard Storage Battery.

il it reaches the level of the hole in the top of the expansion mber,—*i.e.* so that when the top cover is replaced, it will squeeze sealing compound off the top of the expansion chambers.

Thirteenth: Now soften top cover with flame and replace on ninal posts until it rests on top of expansion chamber; then ›e a weight on top cover until sealing compound cools.

Fourteenth: Now, pour sealing compound around the edge o the top cover, until it reaches the top of top cover; then when th sealing compound has cooled, take a putty knife and scoop extr sealing compound off of top cover, making a smooth surface ove all the top of the battery.

Fifteenth: In burning the top connector to terminal post, pr ceed as follows: Scrape the hole of the top connector until th surface is bright and clean; scrape terminal post until top an edge are bright and clean. Now, scrape a piece of lead—preferabl a small bar—bright and clean; then apply hydrogen gas flam mixed with air under pressure, to the top connector and termin post assembled, at the same time heating lead bar. When top co nector and terminal post begin to melt, apply lead bar directly o same, melting it, thus making a firm burned connection. The fill rest of hole-space with melted lead and smooth off even wit top of top connector.

Care of Grinding Wheels.—Chattering and waviness in appea ance of the part finished is usually caused either by the whe spindle being loose in its bearings, the grinding wheel being ou of true or out of balance, or particles of the material being groun having become embedded in the wheel. A loose spindle should, o course, have its bearings adjusted. In a great majority of case however, the cause of imperfect work is due to the wheel gettin out of shape. It is important that its face should be perfect parallel with the travel of the carriage, and in order to produce result of this kind a diamond tool must be used, as near to th headstock or footstock center as is practicable, especially on wor of small diameter. Where the work is not so small, say 2 inch in diameter, the truing device can be clamped at the most co venient point, and in either case it should be carefully seen to th the stud holding the diamond and the arm supporting same, i solid against the work. If the truing device is not rigid the fa of the wheel will not be dressed perfectly true.

It will be observed that the stud in which the diamond mounted can be revolved in its holder and it is important that t point presented to the wheel should be sharp; for instance, if t diamond should become worn and flattened, it should be turn

hus present a new point to the wheel. Keeping the wheel s important for the operator to observe, particularly so when nes to make a final finish. The wheel should be traversed by iamond at a uniform speed, rather slowly in order to give it o cut away the particles. If it is desired to do rapid cutting, it e found proper to pass the wheel by the diamond more rap- hus making a rougher face on the wheel.

ie number of times that the face of a grinding wheel has to ied depends entirely on the character of the work being fin- and the kind of wheel used. There are some wheels that wear rapidly enough so that little truing is necessary. There are ases where a harder wheel is desirable and a hard wheel neces- requires more truing than a soft one. Where pieces are : large and considerable stock has to be removed, it may be ary to true the wheel each time a piece receives its finishing Where the stock to be removed is not more than $\frac{1}{64}$-inch ter it is advisable to finish in one operation, but when there much as $\frac{1}{32}$-inch diameter to be removed it is good practice nd it in two operations. As stated above, it is desirable gen- to present a sharp point of the diamond to the wheel in tru- ut there are times when the smooth surface is preferable, par- rly when it comes to producing a very fine finish; the flat :e of the diamond will tend somewhat to glaze the wheel and roduce a better finish. A coarse wheel properly trued will ce a good finish.

ie amount of wear the wheel is subjected to depends upon erator in many cases. Never bring an emery, corborundum er abrasive wheel suddenly against the work or the work ab- r to the wheel. The feed should be gradual, so that the ing will start almost imperceptibly. Grinding is not intended a roughing process but is a method of finishing in most cases eful manipulation of the feed control is required to prevent heel from "digging" in.

eed for Wheels.—The table below designates number of revo- s per minute for specified diameters of wheels, to cause them 1 at the respective periphery rates of 4,000, 5,000 and 6,000 er minute.

SPEEDS FOR EMERY WHEELS.

Diameter Wheel	Revolutions per Minute for Surface Speed of 4,000 Feet.	Revolutions per Minute per Surface Speed of 5,000 Feet.	Revolutions pe Minute per Surf Speed of 6,000 Fe
Inch			
1	15,286	19,099	22,918
2	7,639	9,549	11,459
3	5,093	6,366	7,639
4	3,820	4,775	5,730
5	3,056	3,820	4,584
6	2,546	3,183	3,820
7	2,183	2,728	3,274
8	1,910	2,387	2,865
10	1,528	1,910	2,292
12	1,273	1,592	1,910
14	1,091	1,364	1,637
16	955	1,194	1,432
18	849	1,061	1,273
20	764	955	1,146
22	694	868	1,042
24	637	796	955
30	509	637	764
36	424	531	637

The medium of 5,000 feet is usually employed in ordinary wo but in specific cases it is sometimes desirable to run them at a lo or higher rate according to requirements. We recommend a nu ber of revolutions equivalent to a surface speed of 5,500 feet. T does not indicate that they cannot be run at a higher or lo speed, but that it is a good average speed to produce good res To allow an ample margin of safety it is recommended that wh should not be run at a surface speed exceeding 6,000 feet. E shop should have a speed indicator in order that the speed o grinding machinery may be known.

Grading of Landis Grinding Wheels.

NUMBERS

The grains are numbered according to the number of m per lineal inch of the sieve through which they have passed. example, No. 30 is a grain that will pass through a sieve ha thirty meshes to the inch, but will not pass through a sieve ha

[redacted]

ε meshes. The fineness, or number, of the emery or corun-
:d in making a wheel determines the "number" of the

;rains (and similarly the wheels) are numbered as follows:
.6, 20, 24, 30, 36, 46, 54, 60, 70, 80, 90, 100, 120, 150. In
the lower numbers indicate the coarser grains, the higher
, the finer ones.

1 ordering wheels, be sure to specify diameter, shape, thick-
e of center holes, the grade and grain or description of
to be ground and speed proposed to run the wheels. If
give shape number.

;rinding hardened steel and cast-iron, wheels made by what
1 as the silicate process give very good results, but the
wheel in our experience is the better for general use.

:t wheel is less apt to change the temperature of the work
ıe glazed.

ıeel is most efficient when just soft enough not to glaze and
ough not to wear away rapidly.

a fine grained wheel for finish, a coarse wheel to remove
For general grinding a 24 combination grain wheel gives
; results.

od practice is to have several grades of wheels on hand
pted for your different classes of work.

ys keep a spare wheel or two on hand for emergencies.

d s	Silicate Process	Vitrified Process	Silicate Process	Vitrified Process	Silicate Process
: E	$\frac{3}{4}$	Soft K	$2\frac{1}{4}$	Hard Q	5
F	1	L	$2\frac{1}{2}$	R	$5\frac{1}{2}$
G	$1\frac{1}{4}$	Medium M	3	S	6
H	$1\frac{1}{2}$	N	$3\frac{1}{2}$	T	$6\frac{1}{2}$
I	$1\frac{3}{4}$	O	4	Very Hard U	7
J	2	P	$4\frac{1}{2}$		

CHAPTER XII

USEFUL INFORMATION FOR AUTO REPAIRMEN.

Anti-Freezing Cooling Solutions—Substances Usually Combined with Wate Advantages of Different Solutions—Electrolytic Action Not Desirabl The Best Mixture—Extinguishing Fires in Volatile Liquids—First Aid the Injured—Schaefer Method of Artificial Respiration—The Repair Sh Medicine Chest—Remedy for Burns, Cuts and Abrasions—Wounds a Painful Injuries—Home-made Aseptic Gauze.

Anti-Freezing Cooling Mediums.—To lower the freezing poi of water it is possible to add various substances and the propo tions added determine the point at which the solution will conge Among the materials commonly used may be mentioned comm salt, alcohol, glycerine and calcium chloride. The alkaline sol tions produce a distinct electrical action wherever two dissimil metals are used together in the cooling system, such as the bra tubing of a radiator and the solder used at the joints; the cast ir water jacket and the aluminum or brass plates used to close t core print holes; the aluminum pump casing and steel or bro impeller, and at many other points which will vary with the sign of the car and the materials of the components. The alco solutions evaporate very quickly, the glycerine solution affects rubber hose, and the salt solutions leave an incrustation as t water evaporates. It is reasonable to expect electrolytic acti when metals of different potential are used together in any alkal solution, which are electrolytes of high value. Taking it all in the selection of the best solution involves a consideration of ma facts and various requirements must be considered in the selecti of that most suitable. Considering the qualities of such a co pound it will be seen that no one will combine all the desira

features, so in selecting the solutions the following should be kept in mind: To begin with, and it is a highly important consideration, the solution used should have no corrosive action, nor should its use prove deleterious on the metals or rubber used in the circulating system. It must be easily dissolved in or combined with water, must be reasonably cheap and not subject to rapid waste by evaporation, and should not be of such character that it will deposit sediment or foreign matter in the jackets, pipes or radiator water spaces. Its boiling point should be as high, if not higher than, that of water, and it should not congeal at temperatures ordinarily met with where it is used.

Substances Usually Combined with Water.—Alcohol is prepared by destructive distillation of various vegetable substances which contain starch or sugar, such as potatoes, beets and numerous grains and fruits. Any starchy material will serve for the production of alcohol and the real question is one of cost, which varies with the locality in which the manufacture is carried on. It mixes readily with water, and does not congeal at any known temperature, though its boiling point is about 175 degrees Fahrenheit, and above this point evaporation is rapid. It is a very volatile liquid and will evaporate at very moderate temperatures. The alcohol generally used is denatured by the addition of a substance which renders it unfit for drinking purposes and because of the recent removal of the government tax it may be obtained for about [illegible]0 cents a gallon.

Glycerine is obtained as a by-product in the saponification of fats in soap and candle making, and is an oily substance which will vary in color from reddish brown when crude to a colorless liquid when pure. Crude glycerine sometimes contains free acids in small quantities though it may be purified and the color removed when it is to be used for certain purposes. This substance has a much higher boiling point than water, ebullition taking place at a temperature of 554 degrees Fahrenheit. Glycerine when pure is a sweet, colorless liquid and is mixable with water and alcohol in any proportion. It is most largely used in the manufacture of nitroglycerine, though utilized to some extent in pharmacy, soapmaking, filling instruments which require a liquid seal and which

are exposed to low temperatures, and sweetening wine. It obtained in single gallon lots at a cost about $1.50.

Calcium chloride is a by-product of the Weldon proces taining chlorine which is to be incorporated into bleaching from manganese ore and hydrochloric acid. It is a salt and duced in the form of crystals, the crude material being ye white in color, though after purification it is clear white. be obtained directly from marble or chalk by dissolving th terials in hydrochloric acid. It is comparatively cheap ar be obtained in 10 pound sheet iron drums at nine cents per Chemically pure its cost will vary from 30 to 60 cents per It is very soluble in water, and while it is in solution it wil the freezing point. It may contain free acid in the crude though this may be neutralized by the addition of a little lime. Water will be evaporated rapidly at temperatures in of 185 degrees and salt will remain in the form of crystals. calcium chloride solutions have been very popular they are well thought of at the present time because of a certain ele action which is set up when the water circulation system i posed of dissimilar metals, as is commonly the case in mot construction and corrosion at the points of juncture is unavo As hydrochloric acid is used when this salt is obtained, ther be some free acid in combination with the cruder grades, and sive action will be noted. The corrosive action of chemicall salt is very slight, though electrical action will be noted similar metals are employed, regardless of the purity of tl in the solution.

Advantages of Different Solutions.—The substances ously discussed all have advantages, some as relates to firs others to freedom from trouble. Alcohol is without doubt tl material to use from the viewpoint of action on metal or r as it does not form deposits of foreign matter, will not fr known temperatures, and has no electrical effect. It is ext volatile, however, and because of its low boiling point will rate at temperatures much less than that of the boiling p water, and the solution in the water circulation system modern motor car often heated to this point, especially wh

ıtural system of water circulation is employed. Combinations of ater, alcohol and glycerine have been tried, and have given ex- llent results. The addition of the glycerine to a water-alcohol lution reduces liability of evaporation to a large extent and in- eases the boiling point. Glycerine and water solutions were form- ly considered favorably, but of late have been abandoned be- use of certain strong disadvantages. Crude glycerine often con- ins free acid, and in many cases, if no free acid is found, it may eak down when exposed to heat, and liberate fatty acids, which re found combined with other elements in all fats and oils of imal or vegetable origin. While this acid may not attack metals any appreciable extent, still its presence in the cooling system not desirable. Glycerine, as is true of most oils, has a destruc- e effect on rubber hose and gaskets, and should not be used in ge proportions on any car where much of the piping system is rubber hose. Glycerine is expensive and is liable to decompose der the influence of heat, and as the proportions used with water larger than is necessary with other substances, these solutions being replaced with alcohol, water and glycerine compounds, ich are most satisfactory in ordinary practice.

Positive Proof of Electrical Action.—To demonstrate that th saline solutions a certain amount of electrical action was un- oidable, the writer made a series of tests in which a number of irs of dissimilar metals were placed in calcium chloride solution d a low reading voltmeter interposed in the circuit showed volt- s ranging from one-fifth to one-half volt, depending upon the tals used, the strength of the solution and the temperature. The ctrical action in every case was greater as the temperature was reased. Extreme care was taken in making these tests, and the ults obtained were carefully checked by another series of tests th the same metals and fresh solutions. The solution used was weakest of the calcium chloride and water combinations, and s made of two pounds of salt to a gallon of liquid. This solu- n has a freezing point of 18 degrees F., only a few degrees lower an plain water. With zinc and copper the current indication was o-fifths of a volt, just half as much energy as obtained with sal- amoniac, a recognized electrolyte, in previous test. The tempera-

ture was about 68 degrees Fahrenheit. Copper and cast showed more energy than when the same elements were imm in standard electrolyte, namely, three-tenths of a volt. Coppe solder showed the same as when sal-ammoniac was used, the in tion being one-fifth volt. When aluminum and cast iron tested the indication was less than one-tenth volt. Aluminum brass produced one-fifth volt, brass and solder one-tenth volt brass and cast iron one-tenth volt. This electrolyte is the we of the calcium chloride solutions which have been advised by who know, for use in the circulation system. Its suitability fo purpose is left to the reader's judgment.

The results with the stronger solution were about the same, only difference noted being that the needle moved over further each stronger solution, though it settled to about the same rea as with the weaker solution for the same elements. All the ments were tested in four different mixtures and results caref noted. To test the effect of increased temperature on current duction, four ounces of the strong solution, that of five pou calcium chloride to the gallon of water, was heated to 180 deg Fahrenheit, a temperature slightly less than its boiling point, the zinc and copper elements placed in the jar and a reading ta While the reading at 70 degrees Fahrenheit was two-fifths volt the higher temperature the indication of the needle was th fifths volt, almost as much as obtained with the regular sal-moniac solution at normal temperatures.

Electrolytic Action Not Desirable.—Where there is ele cal action there is also corrosion and deterioration of the m which acts as the negative element. While it is true that the rent produced between the metals falls off in pressure becaus polarization of the positive element, it must be considered that constant circulation of the solution through the jacket and pi must to a certain extent act as a depolarizer because of agita of the liquid, which has a tendency to keep the surface of the tive element free from gas bubbles. It is reasonable to assume there will be a continued electrical action all the time that the s tion is in a cooling system, though at times this may be very sli To be sure that the action was caused by the calcium chloride a

d not acid in solution the various solutions were carefully tested th litmus paper for acid without detecting the minutest trace. ıen for the purpose of testing the litmus paper a single drop of 'drochloric acid placed in the solution turned the blue litmus a light pink, proving conclusively that the test paper was of ·oper strength. Then consider that all the time the engine is operation the temperature is nearly to the boiling point of the lutions, in some cases more, and it will be seen that the degree of ectrical activity is considerably increased.

The cellular cooler is composed of innumerable soldered joints ıd at every one of these there will be a certain amount of elecical action, which in the aggregate will amount to a considerable ırrent. At various other points of the cooling system, wherever ıere is two unlike metals in combination, we have other small ırrents, which decompose their quota of metal and assist in filling ıe system with sediment and foreign matter, not to mention the lt crystals which will be formed as the solution evaporates. The riter does not claim that the test showed absolute results, but they ›monstrated that without doubt electrical action does exist when lutions of calcium chloride or any other salt are used to prevent eezing.

The Best Mixture.—Plain water and alcohol solutions would the best were it not for the ease with which such compounds ›il and the rapidity with which they evaporate. We have seen ıat the objections advanced against calcium chloride solution have nple foundation and that such compounds are not suitable for e, the chief advantage, that of cheapness, having been eliminated the reduction in the price of denatured alcohol. The addition a little glycerine to an alcohol and water solution reduces liality of evaporation, and when used in such quantities it has no jurious effect to speak of on rubber hose. The tables show the mbinations and their freezing points and the proper proportions the mixtures used must, of course, be governed by conditions of cality, but it is better to be safe than sorry, and make the soluons strong enough for the extremes that may be expected. The riter has used both alcohol and water, and glycerine, alcohol and ater solutions, with good results, though considerable troul

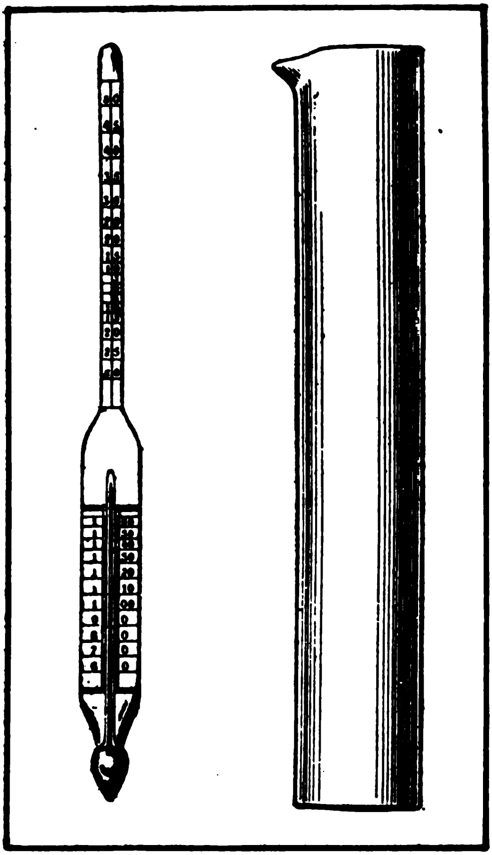


Fig. 465.—Special Testing Hydrometer for Determining Density of Alcohol-Water Cooling Solutions, Giving Freezing Points.

has already bee
rienced when sa
lutions were em
Oils of va
kinds have been
mended, these b
the character
used in lubricat
making machine
made especia
withstand low t
atures. Such o
not absorb heat
as water and
be used only wh
ceptionally goo
ods of cooling a
vided, such as
radiator, all me
ing and positive
This oil will atta
ber hose, howev
it would see
things consider
cohol solutio
preferable to all
The following
tions give the
values of solutio
monly employe

CALCIUM CHLORIDE SOLUTIONS

2 pounds salt, 1 gallon water	**Freezing point, 18°**
3 pounds salt, 1 gallon water	**Freezing point, 1.5°**
4 pounds salt, 1 gallon water	**Freezing point, -17°**
5 pounds salt, 1 gallon water	**Freezing point, -39°**

WATER AND ALCOHOL SOLUTIONS

Water 95%, Alcohol 5%..............Freezing point, 25° F.
Water 85%, Alcohol 15%..............Freezing point, 11° F.
Water 80%, Alcohol 20%..............Freezing point, 5° F.
Water 70%, Alcohol 30%..............Freezing point, -5° F.
Water 65%, Alcohol 35%..............Freezing point, -16° F.

WATER, ALCOHOL AND GLYCERINE SOLUTIONS

Water 85%, Alcohol—Glycerine 15%....Freezing point, 20° F.
Water 75%, Alcohol—Glycerine 25%....Fréezing point, 8° F.
Water 70%, Alcohol—Glycerine 30%....Freezing point, -5° F.
Water 60%, Alcohol—Glyeerine 40%....Freezing point, -23° F.
Alcohol and Glycerine—equal proportions.

EXTRACTS FROM A PAPER READ BY EDW. H. BARRIER BEFORE THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

Extinguishing Fires in Volatile Liquids.—The extinguish-g of fires in oils, gasoline and in most of the volatile liquids has ways been a difficult problem and where fires of this kind occur e results are frequently very disastrous. Our most common extin-uishing agent, water, works rather unsatisfactorily upon the ma-rity of such fires, but it is still the only one available where heroic easures are required. Comparatively recently, however, there ive been two or three other materials introduced for use as ex-nguishers which have shown some promise tor dealing with these es, and it is the writer's purpose to discuss these materials and e conditions under which they prove the most efficient. Not all es in volatile liquids are difficult to handle with water. When e liquid is miscible with water this extinguishing agent can be ccessfully used. Examples of this kind are denatured alcohol, od alcohol, grain alcohol, acetone, etc. Where the liquid is not iscible with water little or no effect is produced except to wash e burning liquid out of the building where it may be completely nsumed, or, if the quantity of oil is small, possibly to extinguish e fire by the brute cooling effect of a large quantity of water rayed upon the fire. Soda and acid extinguishers are somewhat

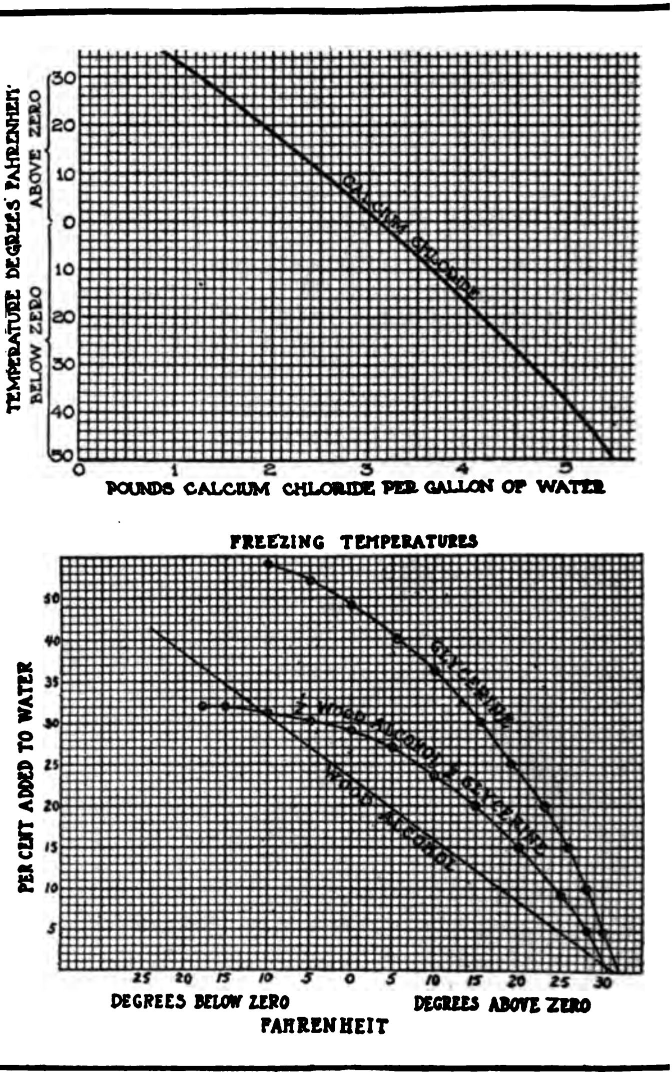


Fig. 466.—Charts Showing Freezing Points of Various Mixtures
Calcium Chloride, Alcohol, etc., and Water.

ore effective than pure water, but even they fail under most con-
itions. The various grenades containing salt solutions which were
ormerly extensively exploited are of course practically worthless.
'he only principles that can be made use of in extinguishing fires
n volatile oils are (a) to form a blanket either of gas or of solid
naterial over the burning liquid which will exclude the oxygen of
he air or (b) to dilute the burning liquid with a non-inflammable
xtinguishing agent which is miscible with it.

Sawdust and Bicarbonate of Soda.—To the blanketing type
f extinguishers belongs sawdust. Paradoxical as it may seem,
rdinary sawdust is an excellent extinguishing agent for certain
olatile liquids, especially those of a viscous nature. A consider-
ble number of experiments were conducted in the fall of 1912 by
he inspection department of the Associated Factory Mutual Fire
nsurance Companies, in the extinguishing of fires in lacquer and
asoline in tanks with sawdust, and the results were surprisingly
atisfactory. The liquids were placed in three tanks 30 inches long,
2 inches wide and 16 inches deep; 48 inches long, 14 inches wide
nd 16 inches deep; and 60 inches long, 30 inches wide and 16
nches deep. The sawdust was applied with a long-handled, light
ut substantially built snow shovel having a blade of considerable
rea. In every case the fires were extinguished readily, especially
n the two smaller tanks which were about as large as any ordi-
arily employed for lacquer in manufacturing establishments. The
fficiency of the sawdust is undoubtedly due to its blanketing ac-
ion in floating for a time upon the surface of the liquid and ex-
luding the oxygen of the air. Its efficiency is greater on viscous
quids than thin liquids, since it floats more readily on the former
han on the latter. The sawdust itself is not easily ignited, and
hen it does become ignited it burns without flame. The burning
mbers have not a sufficiently high temperature to reignite the
quid. The character of the sawdust, whether from soft wood or
ard wood, appears to be of little or no importance, and the amount
f moisture contained in it is apparently not a factor, so that the
rying out of sawdust when kept in manufacturing establishments
or a time would not affect the efficiency. It was found that the
dmixture of sodium bicarbonate greatly increased the efficiency

of the sawdust as shown both by the shortened time and tl creased amount of material necessary to extinguish the fire further advantage of the addition of bicarbonate of soda i it decreased the possible danger resulting from the presence o dust in manufacturing plants since it would be difficult if n possible to ignite the mixture by a carelessly thrown match c other source of ignition. Although the efficiency of the sa is greatest on viscous liquids such as lacquers, heavy oils, ; waxes, etc., in the test referred to, fires were extinguished in line contained in the smallest tank and also when spread up ground. In larger tanks the sawdust or bicarbonate mixtur not work so well since the sawdust sinks before the whole s can be covered, whereupon the exposed liquid reignites.

Carbon Tetrachloride.—In recent years carbon tetrach has received considerable attention as a fire extinguishing This is due largely to the activity of certain manufacturers extinguishers which use liquids, the basis of which is carbon chloride. This substance is a water white liquid and pos when pure a rather agreeable odor somewhat similar to chlor A considerable proportion of the commercial article upo market, however, contains sulphur impurities which impart agreeable odor to the liquid. The substance is quite heav specific gravity being 1.632 at 32 degrees Fahr. It is non-i mable, non-explosive, and is readily miscible with oils, waxes, etc. When mixed with inflammable liquids it renders them inflammable provided a sufficient quantity is added. Its va heavy, the specific gravity being about five and one-half time of air, consequently it settles very rapidly. As an extingu agent it operates by both the principles mentioned, name dilutes the inflammable liquid rendering it non-flammable, least less inflammable, and it forms a blanket of gas or vapo the burning liquid which excludes the oxygen of the air.

Although this exposition is confined to a discussion of guishing fires in oils and volatile liquids, it may not be out of to mention that the claims made by certain manufacturer ducing extinguishers which use liquids, the basis of which is tetrachloride, are grossly exaggerated. These preparations,

hich is more efficient than carbon tetrachloride, are not the 'alent of the ordinary water extinguishers for general use on materials as cotton, wood, paper, oily waste, etc. On volatile ds, oils, etc., carbon tetrachloride has, however, shown very factory results under some conditions, but the readiness with h a fire can be extinguished with it depends to a considerable it upon the skill of the operator and the length of time that iquid has been burning is an important factor, and in such where the sides of the tank become heated the only way in h the fire can be extinguished is to squirt the liquid forcibly e sides. If the carbon tetrachloride is squirted directly into iquid it is much more difficult, if not impossible to extinguish ire. The height of the liquid in the tank is also a very imnt factor. Where the liquid is low the sides form a pocket h retains the vapor and aids considerably in smothering the . When the tank is nearly full, however, this condition does xist, and it is then very difficult, if not impossible, to extin- a fire in a highly volatile liquid such as gasoline; only the skilled operators are successful in these cases.

'he size of the tank or the extent of the fire upon the floor is, ould be expected, of considerable importance. In tanks larger about 28 inches by 12 inches more than one extinguisher and ator working at a time are necessary to extinguish a fire in materials as gasoline. In one test where a tank 60 inches by iches was used no less than seven operators were necessary, even then it was only with the greatest difficulty that the fire put out. All of the above remarks apply to tetrachloride in rdinary one quart extinguisher as generally sold. It is probthat a large extinguisher which could throw a large stream d prove more efficient, but on account of the great weight of on tetrachloride such an extinguisher would have to be spe- designed to make it readily portable by mounting on a truck me similar means. Expelling the liquid by means of a handping arrangement would probably be unsatisfactory, and it d therefore be necessary to force it out in some other way.

. few systems have recently been installed in which an elevated containing tetrachloride was connected with automatic sprink-

s or perforated pipes located in hazardous rooms where
d inflammable liquids are in use. So far as is known
se systems has as yet been called upon to extinguish a fire,
re appears to be no reason why such a system should not
le excellent protection in special cases. In such systems it
necessary to consider the safety of the workmen and fur
dy means of escape, since carbon tetrachloride is an anest
d where thoroughly sprayed through the air as from an
tic sprinkler it would probably produce rapid results.
ture and effect of the fumes given off when carbon tetrachl
thrown upon the fire is a subject which has received a great
discussion. When the liquid comes in contact with a fire
por is partly decomposed resulting in the evolution of a con
ible quantity of black smoke which undoubtedly is divided carb
ngent gases are also produced which appear to be mostly hyd
loric acid with possibly a small amount of chlorine. Since ca
n tetrachloride contains no hydrogen from which hydrochlo
d can be formed this substance must be produced by the acti
chlorine on the gases arising from the burning material or up
moisture of the air. The fumes of carbon tetrachloride althoug
a very pungent nature, do not produce any permanent injury
der ordinary conditions where the operator can make his escape
er he has inhaled all that he can stand, but they are a distinct
ndicap in fighting a fire and are one of the objectionable features
carbon tetrachloride as a general fire extinguishing agent. In
ge rooms or where a small quantity of carbon tetrachloride is
ficient to extinguish a fire the gases are of course less objec-
nable.

Frothy Mixtures.—Another method of extinguishing fires in
s and volatile liquids which has recently been proposed and ex-
rimented with is that of using frothy mixtures. The idea seems
be a very promising one, and the tests which have been thus far
orted indicate very satisfactory results. The idea was origi-
ted and has been developed in Germany. So far as is known no
periments along this line have been conducted in this country.
e process consists essentially in causing two liquids to mix in a
k where foam is produced. The tank is made airtight and

iently strong to permit of the foam being forced out by carbon di-
ide under pressure and the foam is conveyed to the fire by means a line of hose. The exact nature of the liquids has not been sclosed, but one of them probably consists of a sodium carbonate lution containing froth-forming ingredients such as glue or casein d the other an alum solution. The two on coming together gen-
ate carbon dioxide, which produces froth. This froth is reported be quite stiff and to shrink in volume but a comparatively small nount even after a period of half an hour. A number of tests ere conducted in the winter of 1912 in Germany; some of them a considerable scale. In one case as much as five tons of crude phtha in a tank was involved, and in another an area of 1,300 uare feet of burning tar was used. In all cases the results ere reported satisfactory, the fires being extinguished in a short me.

The frothy mixture undoubtedly owes its efficiency to its blank-
ing action in settling upon the surface of the burning liquid, thus cluding the oxygen of the air, and to the fact that the bubbles liquid contain carbon dioxide which, upon bursting, produce an mosphere in which combustion cannot take place. According to e latest report the matter is still in an experimental stage, various tails regarding the form of apparatus, most efficient pressure d design of nozzles being under consideration; but from what s already been done it would appear that the idea is a very omising one.

First Aid to Injured.—While automobile repairing is not assed as a precarious occupation, accidents are frequent in the op or on the road and a knowledge of first aid principles may ten avert more serious consequences and do much to alleviate e pain of the injured person pending the arrival of a competent ysician. The following information may be studied to advantage all interested in mechanical work and by automobile operators well.

Shock: Shock is a sudden depression of the vital powers arising om an injury or a profound emotion acting on the nerve centers d inducing exhaustion. The symptoms are subnormal tempera-
re and irregular, weak and rapid pulse; a cold, clammy, pale, and

profusely perspiring skin; irregular breathing; the person affected usually remains conscious and will answer when spoken to, but is stupid and indifferent and lies with partly closed lips. Always be sure that there is no concealed hemorrhage.

Treatment: Lower the head, wrap the patient in hot blankets and surround him with lamps or other heat giving objects. Give an ordinary stimulant, as black coffee, to be sipped as hot as it can be borne; half teaspoonful doses of aromatic spirits of ammonia may be given every 20 or 30 minutes. Small doses of whisky or brandy may be given, provided there is no hemorrhage. One or two teaspoonful every 15 or 20 minutes will help to tide the patient over until the doctor comes. Inhalation of oxygen is often of much service; artificial respiration may be necessary in some cases. Hot applications over the heart and spine should be used if practical. Always hurry up the doctor.

Fractures: A fracture is a break in a bone caused by a direct or indirect violence. Fractures are the most important class of injuries with which we have to deal, not only because they render the victim a cripple for the time being, but because the further usefulness of the limb depends upon the recognition of the trouble and its proper immediate treatment. Frequently ignorance or carelessness in handling a fracture in the beginning renders the sufferer an invalid or cripple throughout his life.

Treatment: In examining the fracture great gentleness in handling the part should be exercised. The limb should be handled as little as possible. If the nature of an injury is in doubt, it should be treated as a fracture until the doctor arrives. Never allow a person suffering from a broken limb to be moved until the part is properly supported by splints. To treat a fracture, draw the fractured limb into a natural position and hold it there by the application of splints.

Dislocations: A dislocation is a complete separation or displacement of the surfaces of a joint, caused usually by direct violence, but may sometimes be produced by indirect violence or sudden muscular contraction. The symptoms are: Pain, swelling, discoloration, rigidity; the natural position of the limb is changed; the length is altered.

Treatment: Restore the bone to normal position and hold it in lace. To properly reduce the dislocation, some surgical skill and nowledge of the anatomy of joints are required. First-aid men hould never try to reduce any dislocations except those of the jaw nd fingers.

Sprains: A sprain is a twisting or wrenching of a joint, pro-ucing a tearing of the ligaments and sometimes of the surrounding oft parts. It is followed by severe pain and marked swelling and iscoloration. Sprains are important injuries and should be prop-rly treated immediately, as sometimes permanent disability may ollow failure to give them proper care. They are very often more rious than a fracture.

Treatment: Let the injured person rest; elevate the injured art and fix it in place either with splints or by wrapping the oint tightly with a roller bandage or with adhesive plaster. Give ot or cold applications by placing the injured part in hot or cold ater or by the application of towels wrung out of ice water or ot water.

Strains: A strain is the wrenching or tearing of a muscle or ndon and is usually caused by violent exertion or sudden unex-ected movements. A strain generally occurs in the muscles or ndons of the arms or legs. The symptom is sudden, sharp ex-uciating pain.

Treatment: Let the injured person rest; bandage the injured art tightly or apply adhesive plaster. It is sometimes necessary prevent movement of the part by splinting.

Burns and Scalds: Burns are caused by exposure of the body dry heat, such as the heat of fire or explosions of gas and powder, hereas scalds are produced by moist heat, as the heat of boiling ater or steam. The danger from a burn depends upon its depth nd extent, and also on the age and general condition of the per-on injured.

The symptoms in a first-degree burn are: Severe, burning pain, ddening of the skin, formation of blisters; in a second-degree urn destruction of the skin; in a third-degree burn, destruction the skin and some of the tissue beneath. In severe burns shock present.

Treatment: Carefully remove the clothing from the b part, exclude the air as quickly as possible from burned s with some clean covering and treat for shock.

The most generally used covering for burns is picric-acid This is ordinary sterile gauze which has been saturated wit half to one percent. solution of picric acid. It has this advan it is clean and ready for use. Moisten the picric-acid gauz clean water and put it over the burned surface. Over the place a layer of absorbent cotton then apply a bandage t in place.

Carron oil, which is a mixture of equal parts of limewat linseed oil, is often used, and is very good. It is applied as fo Take a piece of sterilized gauze large enough to cover the b surface; saturate the gauze with carron oil and cover the Dress with absorbent cotton and cover with a bandage.

Vaseline, sweet oil, olive oil and balsam oil are all good ings. If nothing better is at hand dissolve some bicarbon soda in sterilized water. Gauze wrung out of this and sprea the burn will give relief. Remember that severe burns are panied by shock, and always treat a burned patient for sh well as for burns.

Schaefer Method of Artificial Respiration: Free the victin electric current conductors or in case of drowning, roll on a to expel water and instantly remove him to fresh air. Rapidl with the finger in his mouth and throat and remove any f body (tobacco, false teeth), then begin artificial respiration a Proceed as follows:

Lay the subject on his stomach with arms extended as st forward as possible and with face to one side so that the no mouth are free for breathing. Let an assistant draw forwa subject's tongue.

Kneel straddling the subject's thighs and facing his head the palms of your hands on the loins (on the muscles of the of the back) with the fingers spread over the lowest ribs 467 A).

With arms held straight, fingers forward, slowly swing fo so that the weight of your body is gradually and without vi

ought to bear upon the subject (Fig. 467, B). This act should ke two to three seconds. Then immediately swing backward so s to remove the pressure, returning to the position swing in Fig. 67, A. Repeat regularly 12 to 15 times per minute the swinging rward and backward, completing a respiration in four or five conds.

As soon as this artificial respiration has been started and while is being conducted an assistant should loosen any tight clothing bout the subject's chest or waist. Continue the artificial respira-

Schaefer method of artificial respiration. Inspiration.

Schaefer method of artificial respiration. Expiration.

Fig. 467.—Illustrating Shaefer Method of Artificial Respiration.

tion without interruption until natural breathing is restore necessary two hours or longer) or until a physician arrives natural breathing stops after having been restored, use arti respiration again. Some patients have been revived after se hours of hard work.

As soon as signs of life appear the lower limbs should b vated and rubbed vigorously toward the heart. Hot applic should be used over the heart if practicable. If the patient consciousness and is able to swallow give hot coffee or hal spoonful doses of aromatic spirits of ammonia and treat as in s Do not put any liquid in the patient's mouth until he is fully scious. Give the patient fresh air, but keep him warm.

Send for the nearest doctor and pulmotor as soon as the dent is discovered.

Automobile Repair Shop Medicine Chest.—The followin tracts are from an article by Dr. W. R. Ingraham published i Scientific American. The instructions are so plainly given they can be followed to advantage by the repairman and mach and the various remedies and supplies mentioned may be a tageously included in the shop equipment because the various accidents that may happen in the shop may be treated by shopmate or member of the clerical force trained for this duty men kept at work after minor wounds are dressed.

Remedy for Slight Burns.—Does the "Handy Man" ever himself? Of course. One of the best, most convenient ren he can use is solution of picric acid in water. It is very satis and just a little gratifying to have the excessive pain of first d burns instantly quieted. First degree burns are superficial the nerve endings, not being destroyed as in the deeper secon third degree burns, set up a howling remonstrance in the w pain. Picric acid of a strength 1 to 200 (about one-third teas ful to one pint of water) or a saturated solution is used. antiseptic and will prevent suppuration. It is analgesic and make it feel good." It stains yellow, but the stain comes o the wash. Keep a small vial handy. When you get a bur skin is not broken), sprinkle a little acid in a basin of water. rate a strip of gauze or cloth with this and bandage in place

very little while (or as soon as the picric acid coagulates the lbuminous exudate) the pain is quieted.

For Deep Burns.—Use picric acid as above for deeper burns blisters and broken skin) but more carefully. Pour a little alcohol n the basin to be used. Roll it about so that the alcohol wets all he inside. Set it on fire and every germ in that pan dies in-tantly. Pour water that has been boiled from the teakettle into he pan, and add the picric acid. Bandage the burn with clean septic gauze and saturate it with solution. Blisters should be pened and contents expressed. Open them with a needle, the busi-ess end of which is sterilized by holding in the flame of a match. 'he soot will do no harm. For still deeper burns or burns of large rea (third degree) much can be done by the above to alleviate uffering until a physician can be had, but send for him at once. 'he attending shock is serious.

For Small Cuts and Abrasions.—If the Handy Man cuts his nger or knocks the skin off his knuckle he should proceed as fol-ows: 1. Cleanse the wound. Hydrogen peroxide is becoming a avorite antiseptic and with good reason. Besides being a germ iller it acts and cleanses mechanically. Its effervescence dislodges nd carries away dirt and any foreign matter that might infect he wound. Try it on a splinter of decayed wood at which you ave picked and fussed in an endeavor to extract. The hydrogen eroxide "boils" it right out. Therefore cleanse the cut by pour-ng on from a bottle a little of it, full strength. (A medicine ropper is convenient.) 2. Dust on a little aristol. Aristol is an odine compound, having the useful antiseptic properties of iodo-orm, but lacks the disagreeable odor and irritating properties of he latter. With the exudate from the wound it forms a good arti-cial antiseptic scab. It may be purchased in small sifting top ottles. 3. Apply a protective dressing.

A bit of absorbent cotton pasted down over the wound with ollodion forms a stiff protecting shield, which stays in place. It nay be washed over with soap and water and will not require re-ewal for two or three days. For a contused finger nail, or cut near he end of a finger so liable to painful knocks it forms a stiff, com-ortable thimble that is soft inside, looks better than a rag and

does not interfere with work. For smaller, more superficial wou than the above a useful dressing, better than the questionable co plaster, or even adhesive tape, is collodion, to which has been add aristol or iodoform (50 grams to the ounce). A small glass rod, th ends of which have been made smoother by melting with a blowp in an alcohol flame, makes a convenient applicator for the collodi Pass it through the cork and leave it in the bottle permanently

For Wounds and Painful Injuries.—In case of a deep wou the collodion dressing is not applicable and the soothing properti of a moist dressing are desired. Pour a measured quart of wat into the basin to be used. Gauge the quantity with your eye. Thro out the water and sterilize the basin (as above) by pouring a litt alcohol into the basin and rolling it about to wet all the inside. Se it on fire with a match and the basin is thoroughly sterilized. Pou a quart of water that has been boiled directly from the teakett into the basin. One tablet of bichloride of mercury (as usually pre pared) makes a 1 to 2000 solution when added to the quart of wate Sterilize another smaller basin by the method described above an pour a part of the solution into it for later use. Cleanse the woun as thoroughly as conditions permit.

Hydrogen peroxide of full strength or diluted with water i usually sufficient. If the wound is very dirty and much lacerate as machinists' wounds are apt to be, the following method of clea ing is perhaps better:

Add to 1 quart warm water in which the wound is to be washe 2 teaspoonsful lysol. (This makes about 1 per cent. solution. Lysol has an odor similar to carbolic acid, but is not so poisonou It forms a soapy solution, hence its value as a cleansing agent. I numbs the parts and makes them less sensitive to pain. The pa should now be thoroughly irrigated with the bichloride solution i the larger basin, being sure that all the lysol solution is remove from the wound.

Surgically clean gauze (sterilized, aseptic) is now bandage over the wound and moistened with the clean bichloride solutio saved in the smaller basin for this purpose. Bandage lightly. I the gauze dries and the wound becomes painful inside of 4 hour remove the outer plain bandage and moisten the gauze with th

ation again. Use weaker bichloride of mercury solution for the ct and succeeding dressing (1 to 4000). If too strong, the heal- g granulations may be retarded.

Home Made Aseptic Gauze.—Plain aseptic gauze (absorbent) ay be prepared at home by the following methods: For each five urds of ordinary cheese cloth use one-quarter pound common wash- ng soda to sufficient water to cover the gauze. Boil for one-half our and rinse in several changes of water to remove the soda. his process removes the fat or oil from the fabric and makes it bsorbent. After it has been dried it is cut into suitable sizes— rips one yard long and four inches wide are convenient. The auze is sterilized and packed ready for use in the following man- er: Screw top jars with caps are placed in a large bread pan, nd the gauze is arranged loosely in the other end of the pan. lace in the oven and bake until the gauze begins to scorch ightly. Remove the pan and all to a table and while hot pack ie strips into the jars. Use a pair of forceps or long tweezers nd a short wire for this purpose. The tips of the tweezers and ire should be made sterile by passing through an alcohol flame veral times, or they may be sterilized by baking with the jars nd gauze. Seal the jars and you have a good supply of aseptic uze ready for instant use. When using the gauze it is well to move the strips with a pair of tweezers, the tips of which have en sterilized in an alcohol flame. This avoids possibility of con- minating the gauze left in the jars. A quick convenient alcohol me may be had by saturating a small pledget of cotton in the outh of a bottle.

Moist bichloride gauze, which is expensive to buy, yet invalu- le in case of accident, is made as follows: Prepare and pack the uze as above. Then prepare a 1 to 1000 solution of bichloride just explained (burning out the pan with alcohol and using iled water). Pour this solution over the gauze in the jars until is thoroughly saturated and allow it to stand for 24 hours. Pour the excess and seal it air-tight. If dry bichloride gauze is de- ed prepare the gauze as above, dry it thoroughly in the oven and pack. However, the moist gauze is to be preferred. In using is gauze observe the precaution stated above, *i.e.*, use weaker

antiseptics after 24 hours and for subsequent dressing. I
picric acid gauze for burns may be made and kept in a jar fo
mediate use as follows: Prepare and pack aseptic gauze, as a
Prepare a picric acid solution in the manner described (1 to
and pour it over the gauze. Let it stand and then pour of
excess and seal it air-tight.

CHAPTER XIII

HINTS AND KINKS

.w Blade Reflector—Holding Polished Pipe—Easily Made Soft Hammer raightening Shaft on Planer—Holding Small Work Without a Vise—ılding Small Work in Vise—Putting on Tools—Illuminated Magnet—moving Keys—Truing Crankshaft—Repair of Broken Gear Case—Sim- Priming Device—Coal Gas for Engine Testing—Warming Manifold · Easy Starting—Stopping Fuel Pipe Leaks on the Road—Use of Tap—me Threading Kinks—Removing a Stud—Removing Stubborn Nut—e of Nuts and Bolts—Placing Nuts in Difficult Places—Forming Rod .ds—Winding Springs in a Vise—Cutting Sheet Metal—How to Make a iped Joint—Forms of Keys—How to Make Keys and Keyways—Wood- ff Key Sizes—Nut Locking Means—Shop Uses of Arbor Press and ıeel Puller—To Make Wood Acid Proof—Sharpening Old Files—Cheap ıckening of Brass—Heat Proof Paint—Etching—Use of Tools—Drilling ıles in Glass—Making a Magnet of a File—Peculiar Cause of Knock- ;—Rust on Tools—Screw Cutting Gears—Restoring Dull Polished Iron Steel—Speed of Grindstone—Cleaning Brass Castings—Pipe Joint ment—Drilling Hints—Body Polishes—Care of Tops—Leather Uphol- ry—Cloth Upholstery.

ıcksaw Blade Reflector Useful.—When sawing metal with a ıw and trying to saw it to a line which has been scribed on ırface the task is found very difficult unless there is good A workman in a shop where the writer was employed made ector for his saw so that it could throw a good light on the A round disk of brass was made as shown at Fig. 468, B. sk was turned so as to have a collar at the back; a slot was cut ;h the center of disk so that it could be slipped over the saw. inch set screw in the collar served to hold the disk in place in use. Some white enamel was spread over the face of disk vide a good reflecting surface. A better reflecting surface result if the disk were nickel plated.

Holding Polished Pipe in Vise.—A very good way to h or rods having a polished surface is to sprinkle dry plaster on heavy paper and roll in this paper the article to be held plenty of powder between the paper and the polished Place the roll between blocks of wood having hollow fa clamp firmly in an ordinary bench vise. When removing th if the plaster adheres to the pipe in hard cakes, do not sc wash the surface in clean water, which will loosen the pla

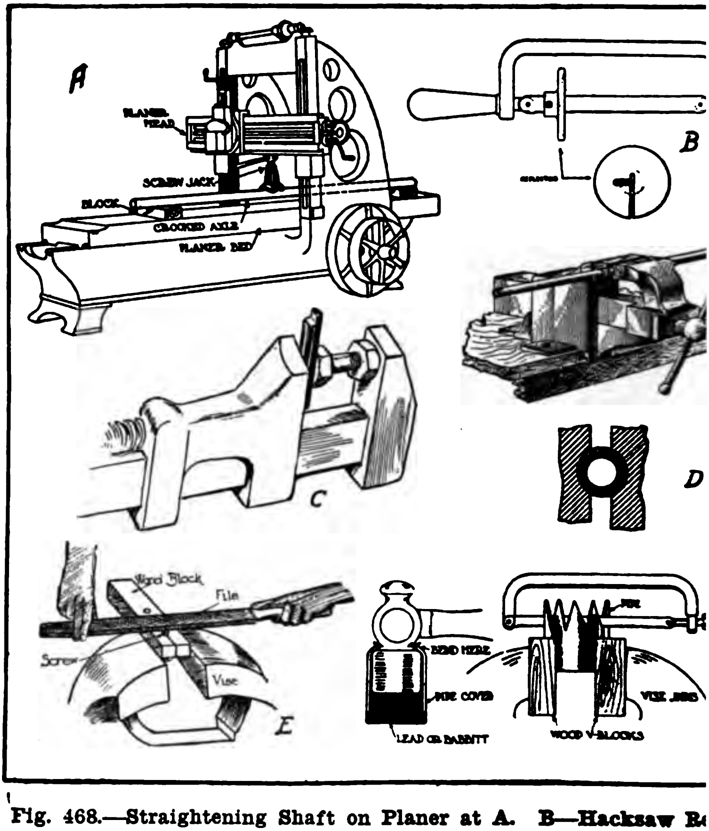


Fig. 468.—Straightening Shaft on Planer at A. B—Hacksaw R C—Holding Small Work Without a Vise. D—Holding Polishe E—Holding Small Work for Filing. F—Making Soft Metal H

ave the pipe in perfect condition. Another method is to place e pipe between pieces of lead sprinkled with plaster, and use pipe vise for a clamp. A means often employed by mechanics to handle quantities of polished pipe is to face the hollowed wood ocks with soft felt, which is sprinkled with crocus or plaster of aris to increase the friction. The method is shown in sketch Fig. 38, D, which is self-explanatory.

An Easily Made Soft Hammer.—A soft hammer often comes handy around an automobile wherever heavy driving is to be one on metal that must not be marred or scratched. Nearly every itomobilist carries a hammer of some sort around and is there- ore loath to believe that another hammer, even a soft-face one, is necessity. Whenever metal parts are to be protected he protects e driven piece with wood, leather, or other soft substance. There nothing handier, however, than having a hammer that is soft nd various types have been made for different kinds of machine op usage, some out of all-metal from pipe and pipe fittings and thers similar to the one in Fig. 468, F. To make this one, use an rdinary gas pipe that will easily slip over the head of the hammer nd cut off a suitable length so that when finished and assembled e proportions will be about as indicated. Saw out any number f V's from the pipe so that when the teeth are bent inward a pring is formed that will snugly catch the head of the hammer. fter the V's are cut out of the pipe, slip the pipe over the head nd arrange for pouring the lead or babbitt. The mold is easily ade by submerging nearly the whole hammer in sand or by filling e space between the pipe and hammer head with putty. Part f the hammer head should be surrounded with the poured metal order to insure a good, close fit, but the fit must not be too close. is well before pouring, to wrap a single thickness of paper around e head, holding it in place with thread or string. Lastly, bend e teeth to produce the spring-locking effect and you have a nice rviceable hammer. As soon as the face is worn it is a simple atter to repair it by melting out the soft metal, and remolding it.

Straightening Shaft on Planer.—It is sometimes possible to raighten a long shaft or tube, such as a propeller shaft or live xle on a planer bed if no straightening machine is available. The

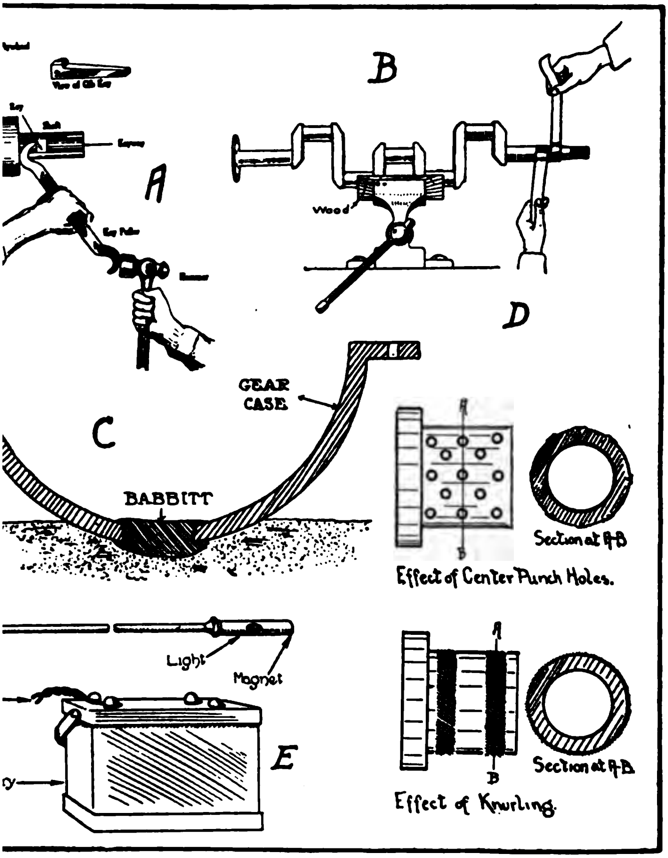
method is clearly shown at Fig. 468, A. The shaft is placed on planer bed resting on wood blocks supported by that member. screw jack is placed between the planer head and on the bent tion of the shaft and pressure is thus easily exerted to straigh the defective axle. This is so placed that the high point is dire under the jack so that the pressure exerted by that member tend to bring the shaft or tube back in line.

Holding Small Work Without a Vise.—It is often neces to make repairs on the road and some minor part must be secu held for filing or other fitting which is difficult to do if a vis not available. A simple method of holding a key or pin or sim small parts is shown at Fig. 468, C. A large monkey wrench, w is included in most automobile tool kits, is used as a vise and w it is difficult to secure the proper degree of clamping pressur the movable jaw adjusting screw alone, sufficient pressure to the key securely may be easily obtained by placing a bolt betv the wrench jaws and the piece to be held in the manner indica Considerable pressure may be exerted by holding the bolt from turning with one wrench and screwing the nut at the en the bolt out against the fixed wrench jaw with another wre If it is desired to hold a round piece a shallow groove may be in the bolt head to prevent it from slipping from the work.

Holding Small Work in Vise.—When filing small screws, b or pins that would be difficult to hold in a vise on account of ger of marring the surfaces the best method is to drill holes wooden block to receive the screw and cut a slot from the en the block down to the hole. When the vise jaws are tightened they clamp the piece firmly and it may be filed with ease as cated at Fig. 468, E.

Removing Keys.—On a number of cars of early vintage, as the double cylinder Maxwell and on many marine engines, flywheel is held on the crankshaft by means of jib keys. W it is desired to remove the flywheel as is necessary to withdraw crankshaft from the engine base when rebushing the bearing, ficulty is sometimes experienced in removing the key. A very fective method of accomplishing this is shown at Fig. 469, A. key extractor or puller is forged of steel as indicated having

he ends formed on curves of different radii. The one : more gradual curve is used first to start the key while ving more abrupt curve is employed for withdrawing it. key puller is placed between the head of the key and the flywheel a cam action is obtained by which the pressure ımer blows on the other end of the key puller is increased



-A—Removing Jib Key. B—Method of Truing Crankshaft. pair of Gear Case with Babbitt Metal. D—Use of "Putting- Tool. E—Illuminated Magnet.

many times and the key easily started. If the key is rusted in pl or if it has not been removed for a long time it may be found de able to heat the end of the shaft with a blow torch or to soak t rusted parts with kerosene.

Truing Crankshaft.—The method of holding a crankshaft wh it is desired to true the crank pin journal shown at Fig. 469, B, a very practical one and is followed by a number of mechan when overhauling an engine. The journals are often not rough up enough to warrant dressing them down in a lathe, so the cra shaft may be securely clamped in a vise between wooden blo and the journals dressed down with strips of emery cloth or wi a leather belt or strap covered with oil and abrasive material.

Repair of Broken Gear Case.—An emergency repair of t gear case that has been injured by a nut falling between one the gears and the bottom of the case is shown at Fig. 469, C. T repairman who made this repair did not have an autogenous we ing outfit so the hole was filled up with babbitt metal as shown.

A Putting-on Tool.—How often at some time or other, ha mechanics wished for something in the way of a putting-on to As it is always easy if a piece is too large, to remove metal order to bring it to proper size this proposition does not worry ev the poorest mechanics. But what is to be done if the piece is small? A common method and a brutal one is to take a cen punch and upset the surface of the metal, in order that it shall a tighter fit in the hole. A bushing or a rod, if not too small, often treated in this manner, and may be forced into the hole. more effective method of "putting on" is by means of a comm coarse knurl, knurling the bushing the entire circumference several places. This will have the effect of expanding the outs diameter almost $1/32$ of an inch, if desired, and is much neater a infinitely superior to the use of prick punch marks, which is unsightly and unreliable method of increasing the effective dia ter. The great advantage of knurling is that the metal is equa and uniformly expanded, does not look bad if for any reason bushing or rod is withdrawn and what is more important for a thing that must be a tight fit, it will never work loose.

Illuminated Magnet.—An electric searchlight and electro-m

nt has been brought out by an English concern and should prove useful tool in repair shop. It consists of a handle, on one end of hich is the magnet, while above the latter is an electric bulb which nds light through two windows, as presented at Fig. 469, E. A exible cord passes through the instrument and is attached to a storge battery or dry cells. The magnet is utilized to pick up nuts, olts or pieces of metal that may drop into the crankcase or other laces not easily reached by hand, and is said to be sufficiently owerful to attract a good sized wrench. The light facilitates findig the parts, may be used to ascertain the amount of gasoline in e fuel tank or lubricant in the crankcase and to inspect other laces. In addition to being handy in the garage it could be inuded in the tool equipment of a car and used in connection with e roadside repairs.

Simple Priming Device.—Several simple priming devices may constructed by anyone of average mechanical ability to facilitte motor starting in cold weather. One such equipment is shown Fig. 470, B, and comprises a dash priming cup, tubing conecting it with the intake manifold, and a spraying device, which shown separate in the drawing. It will be noted that the last med member is perforated. To utilize the primer a little gasoe is poured into the cup on the dash and the lever turned slightly admit the fluid, also a little air. The fuel flows through the tube the perforated member, and upon cranking the engine, the air awn in through the carburetor and petcock breaks up the fuel, nverting it into a rich mixture. It is stated that the motor will rt on the second or third crank even in the coldest weather. The terial required to install the primer consists of a petcock, which secured to a plate on the dash; a connector having a tubing and pipe thread end, ¼-inch annealed copper tubing, and a union. the last named is soldered a piece of brass tubing which is illed full of No. 62 drill holes. Its length should be approxitely that of the diameter of the intake pipe into which is inrted by drilling and tapping a hole. The manner of installing parts is clearly depicted in the drawing. It is stated that the uipment described can be made at a slight cost. A simpler inllation is shown at A, this consisting merely of a petcock

threaded into the intake manifold. It has the disadvantage that it must be reached to be filled by raising the hood. The owner of a model T Ford states that he has obtained increased mileage by the use of the primer, as the petcock on the dash may be opened to admit auxiliary air. In average running in warm weather he has secured 26.5 miles to the gallon, and 32 miles in long trips.

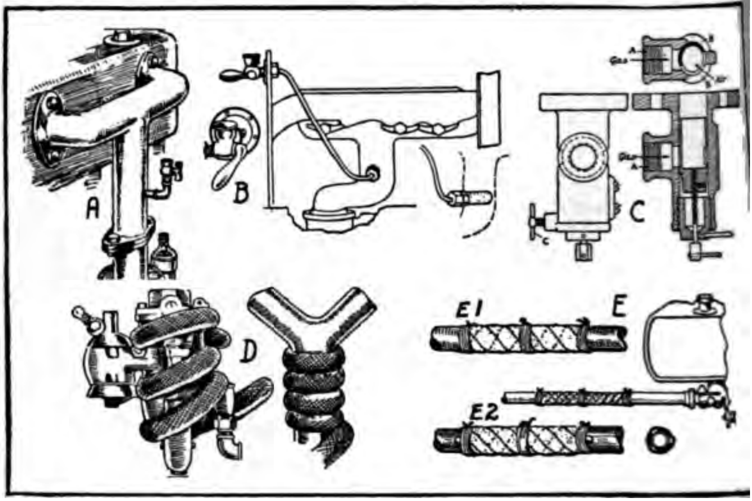


Fig. 470.—A—Simple Priming Device. B—Simple Priming and Au iliary Air Device. C—Coal Gas and Air Mixer. D—Method Warming Carburetor. E—Emergency or Fuel Pipe.

Coal Gas for Testing Engines.—The Willys-Overland C Toledo, Ohio, uses city gas for testing and "running in" engi in its testing department. The company has constructed a speci mixer which fits the inlet manifold and takes the place of the ca buretor. This is shown at Fig. 470, C. The housing is a cast ir cylinder having a threaded boss on one side for attaching to t gas supply at A. Level with the gas inlet are two air ports, B. Threaded into the bottom of the housing is a plug, the object which is to rotate a sleeve immediately above it around in o direction or the other as may be required for the adjustment; t

ve is connected to the threaded plug by two sliding keys (not wn in drawing).

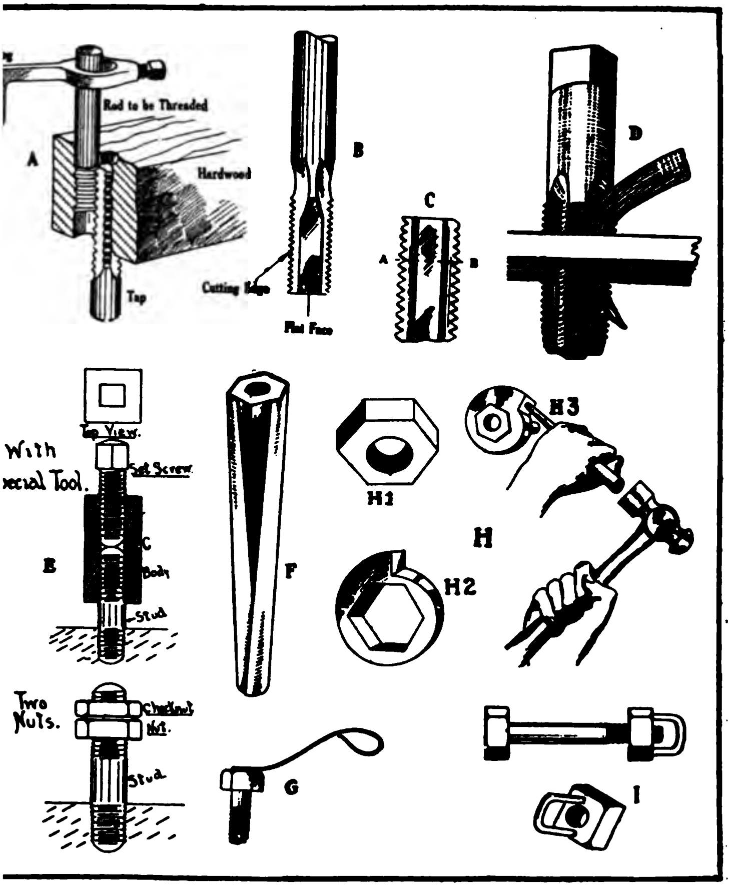
Running through the plug is a rod threaded at the upper end ch permits of the sleeve being raised and lowered as may be uired, but which will not rotate it on account of the sliding s that move up and down in corresponding slots in the plug; plug is locked in position by the screw, C. When setting the er in testing an engine, the sleeve is first rotated by the plug btain the correct proportion of gas and air, usually to a posi- as shown in section AA. Note that the gas supply is con- rably smaller than the amount of air allowed. When this ad- ment is made, the plug is locked by screw C. Then the speed he motor can be regulated by raising or lowering the sleeve with threaded rod running through the plug. This makes a very ple and inexpensive device which is entirely satisfactory. Be- s saving fuel, it does away with the danger from split gasoline he test shed.

Stopping Fuel Pipe Leaks.—One of the simplest emergency hods is to utilize a section of rubber tubing which is slipped r the metal pipe, but if the break be in the center of the line vibration would tend to chafe the rubber. The latter should braced by splints and the manner of attachment is shown at . 470, E. Where this is not obtainable a repair may be made n ordinary friction tape. Strips of wood are laid lengthwise a first winding of tape and in the same direction as the line the outer tape wound as depicted at E 1, being tied with twine. wrapping should be snug where the break occurs to prevent age of the fuel. A small crack may be treated in a similar nner or by using soap and tape as the former is not affected by line; in fact, a piece of this material is invaluable in the tool Shellac may also be used in conjunction with tire tape. A e of rubber hose from the acetylene gas line may be used to join broken pieces of tube temporarily.

Warming Manifold for Easy Starting.—One finds numerous ructions for easy starting of a gasoline engine under conditions ow temperature when the gasoline does not evaporate readily. e ill advised writers have recommended the use of hot cloths

heated by being saturated with boiling water, others have bea vised to heat the manifold with an ordinary blow torch. Th cessity of keeping the naked flame away from gasoline is app to any one familiar with this liquid and it is also evident water dripping from a saturated cloth in through an auxiliar valve so it would get into the carburetor mixing chamber w cause considerable trouble on account of being matter out of p An excellent method of heating a carburetor or manifold wi any danger is to use a tube of cloth or long bag which is filled sand and placed in an oven after which it may be wrapped ar either the carburetor or manifold as shown at Fig. 470, D, wi any danger of fire as is present when a torch is used or g water into the carburetor as is possible when wet cloths ar ployed as a heating medium.

The Use of the Tap.—The true mechanic can always be l by the way he uses his tools, and care must always be take the right way is employed, because improper use has shorten life of many good tools. Taps and dies are commonly abuse often broken. You will never see a thorough mechanic u monkey wrench on a tap. He will tell you that there is a on force against the tap, especially if the metal being threade all hard, that will invariably break the tap. It is obvious t wrench supplied and called the tap wrench is all that sho used for this purpose, as both its arms are of equal lengtl there are no bending strains against the tap. Then there is t fortunately most of these are used with the proper holder, as a die stock, and they are not as easy to break as the more tap. The end of the blank rod which it is desired to thread be carefully filed or turned to a slight taper, so that the c fit it with ease, and have a chance to start. Then care must served to prevent wabbling of the die, which might break s the cutting teeth, or would cut a very inaccurate thread. W is desired to cut threads to a shoulder the die may be us regular way as far as possible and then reversed, which w threads right to the shoulder. Never try to start a die w reverse side, because it will be practically impossible to ol good thread.



471.—A, B, C, D—Illustrating Use of Tap. E—How to Remove tuds. F, G—Placing Nuts and Bolts in Difficult Places. H—How Remove Stubborn Nut. I—Easily Made Thumb Nut.

he care to be used with a tap or die varies according to the ·ials to be threaded. If cast iron or brass be tapped, a mini- of the lightest cutting oil should be employed, whereas ght iron or steel will require the constant use of a cutting Never use machinery or cylinder oil with a tap or die; lard oil

should always be at hand for this use. In iron or steel the tap should be worked in gently, and with quarter turns backward and forward as soon as it begins to take hold. If the hole is deep, oil must be used and the tap removed occasionally to clear it of chips. Tap sets are usually composed of three of each size, two of which have an appreciable taper at the end, the other is the same size all the way, and is slightly chamfered at the end. That with the greatest taper or "leading" tap is used first, followed by the next one, which is known as the No. 2 or "following" and last of all the No. 3 or "bottoming" tap. The bottoming tap should never be used except after both of the others have been used as far as possible. A bottoming tap is very useful to clean out or enlarge a thread that is already tapped but which may be a trifle small.

Some Thread Cutting Kinks.—The repairman often has occasion to cut left hand threads in nuts or on bolts and it sometimes happens that a left hand tap or die is not available at the moment. A right hand tap can be used to thread a rod to make a bolt or for tapping a nut with a left hand thread by observing a few simple precautions. The illustration at Fig. 471, A, shows how to thread a rod with a right hand tap so it will act in the same way as a left hand die. Two holes are drilled in a piece of hard wood in such a manner that they cut into each other, the size of the holes being equal to the diameter of the piece to be threaded. The tap is screwed into one and held rigid, the other serves as a guide for the bolt or rod upon which the threads are to be cut, causing it to bear against the outside cutting edge of the tap. By turning the rod in a left hand direction a left hand thread will be cut, both the pitch and cutting edge of the tap being true enough for the purpose. Parallelism of threads will depend on the operator.

When the tap is to be employed in tapping out a nut, the alteration shown at Fig. 471, B and C, is necessary. A four-fluted right hand tap is changed into one having but two cutting edges by grinding off two of the flutes. On considering the remaining two cutting faces, it will be seen that the point of the thread on one side is on a line with the bottom of the thread on the other. This form of tap will cut either right or left hand threads depending upon the direction of rotation. Steel and brass, as well as

-on, have been tapped successfully by this method. After a tapped, should it prove too small for the bolt it is intended, it may be easily made larger. A small piece of tin is pla over the end of one of the flutes of the tap, as shown at Fig. 471, the tap is "run through" again and it will be found that the pi tin crowds the tap to one side and cuts a considerably lar hole than before. If the nut should not prove large enough, other piece of sheet metal may be placed over the first one, wh has assumed the contour of the threads.

Removing a Stud.—Nothing marks the slovenly mechanic m than the methods he employs in performing his work, as well the use of the improper tools for different operations. He cheerfully use a screw driver as a cold chisel or a monkey wren as a hammer, with but little care of the consequences, both to tool and the work. It is this class of "mechanic" who will use Stillson or pipe wrench upon a stud in essaying to remove it fr the work, marring the appearance, as well as often destroying usefulness by injury to the threads. Two methods are shown Fig. 471, E, of removing a stud without damage to any part, simplest being by the use of two nuts, the more mechanical means of a simple device or tool. Where two nuts are employed is used as a check or lock nut for the other. The two nuts tightly locked to each other and the pressure to remove the st is applied to the lower one. It may be necessary to hold the nut by means of another spanner or end wrench to prevent it tu ing upon the stud instead of with it.

A very efficient and simple device for removing studs may made by any ordinary man familiar with the use of tools. T consists of a body C which may be made of a piece of hexago or square stock; either bronze or steel is preferred to cast iron, cause the threads are much stronger in such metals. A hole drilled through of suitable size and a tap is run down through hole and a suitable thread cut to fit the stud to be removed. cap or set screw (A) completes the device. To use, the body screwed upon the stud for a certain distance and the set screw then screwed tightly against the end of the stud. If the body *made of round stock,* flats should be filed on the sides in ord

hold a wrench. If square stock is available, it will be prefe This device is very handy and should be made in several size the various standard stud sizes which are mostly used in me cal work. A set should form part of every mechanic's person because they are inexpensive, and when required are worth weight in gold.

Removing Stubborn Nut.—While a stubborn stud or sh bolt is difficult to remove, one can usually unscrew a nut wi much trouble, even if it has become more or less rusted in A good method to take off a nut that seems to resist being p from its stud or bolt more than usual is to heat an open sp that fits the nut and let it rest against the nut for a few mi The heat will sometimes expand the nut without producing sponding expansion of the bolt and it may be unscrewed. spanner or end wrench may be heated in a blow lamp flam while this kink is very old it is not generally known. One s not heat a hardened wrench or an adjustable member as it n rendered unfit for use. The blow lamp flame should not be a to the nut direct because the bolt will be heated and will e as well as the nut. Kerosene may be poured around the t with good results, especially if the nut has rusted in place. S alternate heatings and applications of kerosene oil may be 1 before the nut is loosened and if it still resists, a light tappin a hammer on all the facets while it is hot may assist in ha become looser on the threads.

Use of Nuts and Bolts.—Most of the parts of the motor held together by what is known as a bolt and nut, especi the component is one which must be removed from time t for inspection, adjustment or repair. There is no part of t which is subject to more abuse than the bolts and nuts, and parts are often damaged by carelessness or ignorance so th ones must be used. This is not a serious matter if the l a standard form, but if a special size fitted with an odd t it must be evident that a new one can only be obtained fr factory or made at the local machinist's at some expense. I culty is found in causing a bolt used to hold together two p fit the holes with ease, the chances are that the two pieces a

ed angularly, and one should not attempt to put in the bolt by e force. A good plan is to use a taper punch, smaller than the at the point and larger at the other end, this is first driven the hole, and tends to bring the parts into proper alignment so the bolt may be easily inserted.

Many bolts and studs and their nuts are damaged by care- iess in starting the nuts cross threaded, and then using a wrench orcibly turn them on. Nuts should be carefully started with fingers and one should ascertain that the threads engage prop- before pressure is applied. Bolts are very often spoiled in ing them out from the parts in which they are located. If do not start readily one is often tempted to use a hammer n them, with the result that the ends of the threads are burred and one has trouble in replacing the nut. A stick of hard d, a piece of fiber, or a junk of soft brass, copper or lead should nterposed between the hammer and the end of the bolt to pre- t damage of this kind. Most mechanics have either a lead or per hammer for this purpose, and the writer has seen motorists' which had this useful tool, or its equivalent, a wooden mallet. re are many uses for such a tool, as driving on or off the various parts, either of brass, aluminum, or cast iron, which would be ted and damaged by the steel hammers generally used.

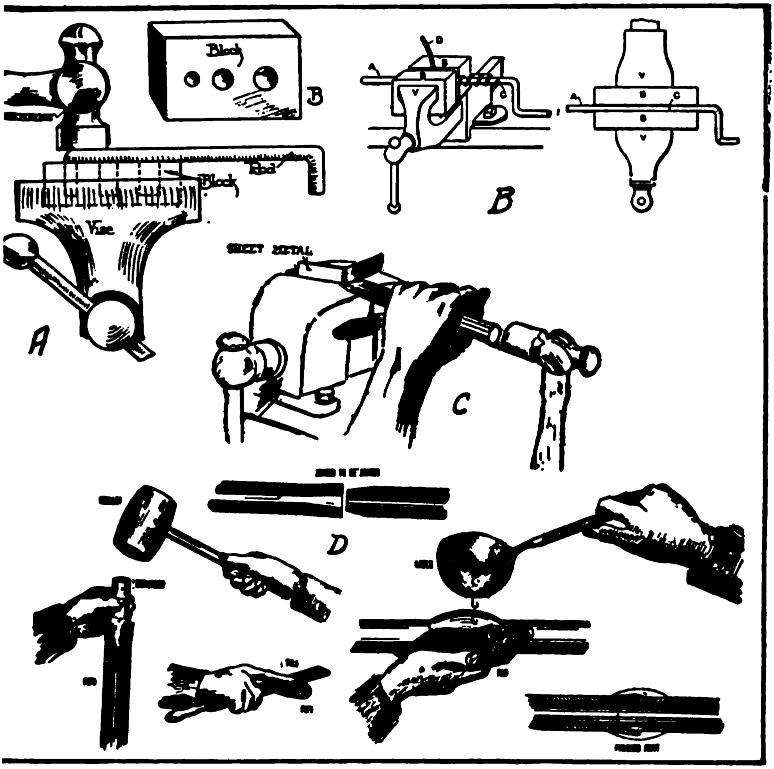
Starting Bolts and Nuts in Difficult Places.—Recently while king on an automobile it was found difficult to get a bolt started ts place, and when the writer had about decided to remove other ts to enter the bolt, the following scheme of overcoming the culty was tried. A piece of wire was procured and one end tly soldered to the bolt head. This served as a handle for ing the bolt and was easily removed by giving the wire a few ıs. The same means can be used to enter bolts and pins in es not easily accessible, the time of preparation being small as pared with the practical value of the device. (See Fig. 471,

A simple method of starting a nut is shown at Fig. 471, F. holder is made of sheet metal, rolled into a tube. A nut is ı inserted in one end and the metal hammered to the shape of nut. Any length of metal can be used, as desired. In use, the ɔed end of the metal is slipped over a nut and a slight pressure

suffices to screw it down over bolt. For starting nuts on the end of a bolt in a location not easily reached with a wrench the simple tool shown at Fig. 481, H, will be found valuable. This is made of steel and has a projecting lip against which a drift may be placed as at H 3. The nut may be started by hammer blows without damage. Burred threads on a bolt may be cleaned up by using an extemporized die made from a nut of the proper size as at H 2 by cutting a series of three grooves in the threads with a three cornered file to provide cutting clearance and then case-hardening the nut interior.

Forming Rod Ends.—Many of the minor control rods such as is used for advancing the timer, manipulating the throttle or working the muffler cutout are simple steel rods with the ends bent over to be pushed through the eye of the levers they connect. A simple method of making these rod ends is shown at Fig. 472, A. A block of steel is drilled with three or four holes to conform to the sizes of rod ends most generally used. It is well to have the holes about one sixty-fourth inch larger than the rod size. The writer would advise making holes, one-eighth inch, three-sixteenths inch, quarter-inch and five-sixteenths inch in the block. When making the rod end, the block is held in the vise and the rod, which is either Norway iron or mild steel is thrust into the block to the desired depth and then bent over with a hammer as indicated. In bending the rod this should be done slowly and with as much care as possible and the rod should preferably be heated to a red heat before bending.

Winding Springs in Vise.—Small springs are often needed in repairing automobile parts and in some cases a spring winder or lathe is not available for making the spring. The illustrations at Fig. 472, B, are reproduced from a recent issue of Machinery and the device shown is a very practical one as it uses parts found in every garage. A rod A is selected that will give the correct inside diameter to the springs. The diameter of this rod must be determined experimentally as there must be some compensation for the enlargement of the spring when released. This, of course, means that the rod must be less in diameter than the inside diameter of the finished spring. The rod is bent at one end to form a crank



'ig. 472.—A—Method of Forming Rod End. B—Winding Spring in a Vise. C—Cutting Sheet Metal. D—How to Make a Wiped Joint.

hole C is drilled near the crank end which should be large enough allow the end of the spring wire to enter. The tool is clamped tween the vise jaws B and the wood blocks D. The rod A should clamped with the crank as close to the blocks as possible with e wire in a vertical position. As the crank is turned, a groove is t into the wooden block which acts as guide for the wire D, the ımber of coils or pitch of the spring being determined by the ıount of inclination of the wire. The greater the inclination the der the spacing. The first turn of the crank must be very carelly made as it determines the pitch.

Cutting Sheet Metal.—When a strip is to be cut from sheet

metal, instead of laying the sheet down on an anvil or bench and cutting with a chisel by hammering against the chisel wl placed vertically in respect to the block the method shown a 472, C, is recommended. This gives a shearing cut which will a smoother edge and not be liable to damage the edge of the as is done when that tool is driven through the sheet metal an the backing block. The piece of sheet metal to be cut is cl between the jaws of the vise, just enough of the metal bei lowed to project above the vise jaws as corresponds to the of the piece to be cut. By cutting with a shearing action manner indicated it will be possible to cut off the strip sm with very little exertion and without damaging the chisel e

How to Make a Wiped Joint.—The wiped joint is a for is very popular with plumbers when joining lead pipes, but also be used to advantage by the repairman in making joi the copper tubing used for acetylene gas oil and fuel lines some cases the larger copper pipe employed for water mar The various steps are shown at Fig. 472, B, the proportions pipe or tube being greatly exaggerated in order to make the] clear. The first step is to expand one end of the tube by c in a small conical expanding tube, taking care to hold th firmly between wood blocks in the vise while this operatio progress and to expand the pipe by a series of light taps than heavy blows. If the expanding tool is held too hard it to spread the pipe. The end of the tube to be joined wit one which has been previously expanded is filed down tape order to fit the expanded section of the other piece. The pa well coated with soldering flux and molten solder is poured joint from a small ladle, this being wiped by a pad of felt w well waxed and which is used to wipe the molten metal symmetrically shaped mass to form the substantial joint as in the sectional view at the lower right hand corner of the tration. If care is taken to have the pieces of pipe cleaned they are joined and to have reasonably close fits between th and female taper a very satisfactory joint may be made little practice.

Forms of Keys.—Many parts of automobiles which m

moved from the pieces to which they are fastened and by which ey are actuated are held by a method of fastening called "key-g." Various forms of keys are shown at Fig. 473, that at A be-g a form made from ordinary key stock which may have either unded ends or square ends depending upon whether the key is be set into a keyway machined into the center of the shaft or one end. If the keyway comes in the middle of the shaft, a und end key such as shown at A is generally used. If the key-y is at the end of the shaft, the key is apt to be a form having uare ends. Key stock is procured in various standard sizes and usually made smooth enough when manufactured so that no great nount of fitting is needed to insert it in the keyway. The key own at B is known as the Woodruff key and is a very popular rm in automobile construction. It is commonly used for securing ch parts as gears, cams, and rocker arms to shafts. The taper ns shown at C is a favorite method of retaining brake actuating d control levers to the shaft operating them. The straight pin own at D may be used in two ways, it may be driven entirely rough the shaft and the hub of the lever and then headed over it may be driven into a drilled hole which is made after the ar or piece it is to hold is in place on the shaft, the hole being illed in such a way that half of it is in the gear and the other lf in the shaft. The use of a taper pin is clearly shown at F hile that of the round pin or key shown at D is outlined at G. he half round keyway for the Woodruff key is shown in the taper d of the shaft outlined at E as is the method of making a tem-ate to obtain the radius of the Woodruff keyway when it is de-red to fit a new Woodruff key or to determine the size of the yway if the old key is lost.

The method of making the taper pin lock is a simple one. A raight hole is drilled through the boss of the lever and the shaft, e drill size being the same as that of the small end of the taper n. Taper reamers may be obtained to conform to the taper of e standard taper pin and these are employed to produce the rrect taper in the straight hole in order that the corresponding per pins may be a tight drive fit in both shaft and lever boss.

How to Make Keys and Keyways.—The method of laying

a keyway when the rounded end key shown at Fig. 473, A, is t
placed in a shaft is shown at Fig. 474, A. The outline of the
is scribed on the shaft, care being taken to have the curved
a half circle whose radius is equal to half the width of the k
For example, if the key is supposed to be one-quarter inch w
and two inches long the first operation will be to describe a strai
line along the shaft and to indicate thereon the useful length
the key which is that of the straight portion by center pun

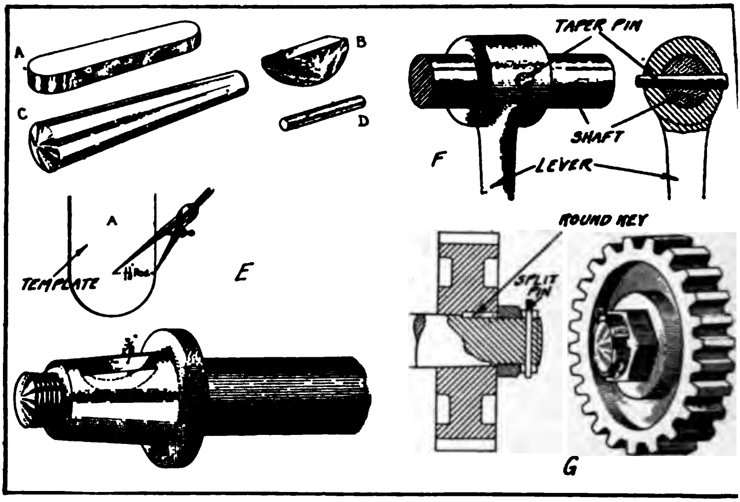


Fig. 473.—Forms of Retaining Keys and Their Use.

marks on the line. The dividers are then set to one-eighth i
radius and circles are drawn using the punch marks as cent
The sides of the circles are then joined by lines parallel to
center line. The next operation is to drill a series of quarter i
holes into the shaft as shown at Fig. 474, B. These are cut out
means of chisels such as shown at Fig. 474, C. The operation
started with a narrow chisel, followed through with the medi
width chisels and finished off with the wide one which is accurat
ground to the correct width of the keyway. A piece of quar
inch keystock is then obtained cut to the proper length and t
ends rounded off with a file or on an emery wheel, to confor

e shape of the keyway. The method outlined is of course, used ly where regular keyway cutting machinery is not available, as ɔuld be the case in a small repair shop where milling machines shapers are not included in the machine tool equipment. The ethod of making a keyway in the end of the shaft is similar to at for making one in the middle of the shaft except that it is

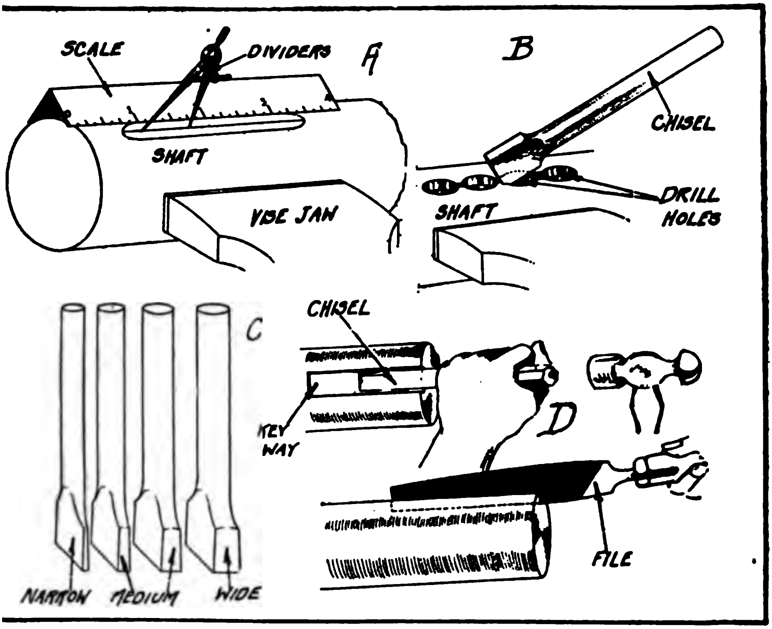


Fig. 474.—Methods of Cutting Keyways in Shafts without Machine Tools.

uch easier to chisel out the keyway with a cape chisel and finish with a file as shown at Fig. 474, D.

The Woodruff key may be obtained in a wide variety of sizes ıd in different materials. It is a very simple form to make if a ·y of the right size is not available. A very satisfactory Woodruff rm key may be made from a bar of round stock of the desired aterial and radius as indicated at Fig. 475, in views A to F, inusive. The first step is to saw into the end of the rod as shown

at A, then to cut into the side of the rod with the saw as shown
B, this permits the piece of stock to break away as shown at
Of course, the key is cut wider than the keyway it is to fit as
as longer than the regular size key. The operation of filing
sides and face to produce the finished key shown at F is clea
outlined at D and E. The keyway for a Woodruff key can be m

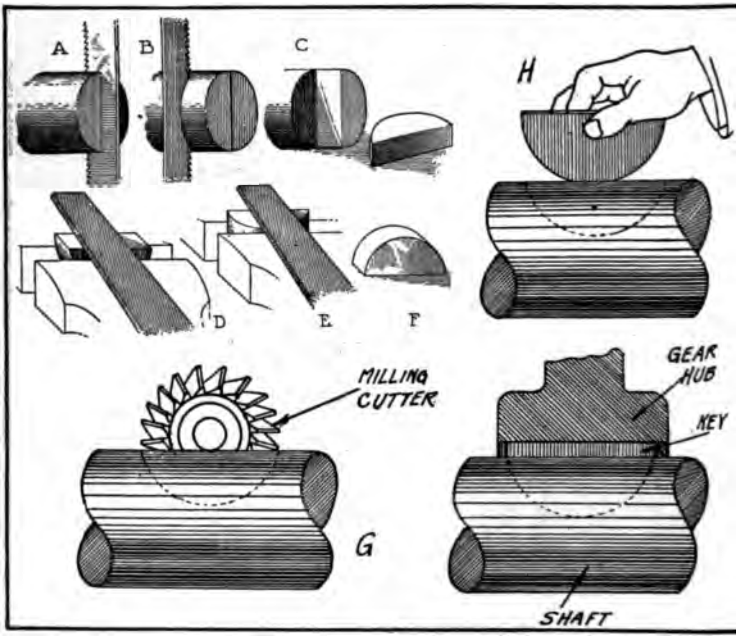


Fig. 475.—How to Make a Woodruff Key, Cut the Keyway and Method of Using.

only by a special milling cutter made for the purpose. It is
necessary to have a milling machine to use this milling cutte
very satisfactory results can be obtained by putting it in a l
or drill press chuck. The depth to which the cutter is fed
the shaft is clearly shown at G. The key is then placed in the
way as outlined at H and the hub of the part it is to retain is fo
over the key and shaft as shown in the lower right hand corne
Fig. 475. Care must be taken when fitting any form of retai

n or key to have this a tight fit in its keyway as if keys are fitted ›sely so that some degree of movement is permitted between them .d the keyway and the shaft or the part it drives, sufficient lost ɔtion may develop so the key will be sheared off. This applies pecially to keys subjected to variable or sharp loads as in those ıployed for holding flywheels, driving wheel hubs, or transmis-›n system parts.

Woodruff Key Sizes.—Each year sees the use of more and ɔre Woodruff keys for fastening gears and similar parts to round afts, for which reason the various sizes are of considerable in-rest. A table herewith gives the various sizes which are referred in the sketch above, the letters in the table corresponding with ose in the figure. There are 30 standard and many special sizes.

Io. of Key	Diameter	Thickness	Depth in Gear	Less than ½ Diameter
	a	b	c	d
1	.500	.0625	.0312	.0468
2	.500	.0937	.0468	.0468
3	.500	.1250	.0625	.0937
4	.625	.0937	.0468	.0625
5	.625	.1250	.0625	.0625
6	.625	.1562	.0781	.0625
7	.750	.1259	.0625	.0625
8	.750	.1562	.0781	.0625
9	.750	.1875	.0937	.0625
10	.875	.1562	.0781	.0625
11	.875	.1875	.0937	.0625
12	.875	.2187	.1094	.0625
A	.875	.2500	.1250	.0625
13	1.000	.1875	.0937	.0625
14	1.000	.2187	.1094	.0625
15	1.000	.2500	.1250	.0625
B	1.000	.3125	.1562	.0625
16	1.125	.1875	.0937	.0781
17	1.125	.2187	.1094	.0781
18	1.125	.2500	.1250	.0781
C	1.125	.3125	.1562	.0781
19	1.250	.1875	.0937	.0781
20	1.250	.2187	.1094	.0781
21	1.250	.2500	.1250	.0781
D	1.250	.3125	.1562	.0781
E	1.250	.3750	.1875	.0781
22	1.375	.2500	.1250	.0937
23	1.375	.3125	.1562	.0937
F	1.375	.3750	.1875	.0937
24	1.500	.2500	.1250	.1094
25	1.500	.3125	.1562	.1094
G	1.500	.3750	.1875	.1094

These sizes vary from .5-inch diameter and .0625-inch thickness up to 1.5-inch diameter and .375-inch thickness. The general shape of the keys is that of a coin cut into halves, although to be exact the half is not complete, as the sketch shows. The key is set down into the shaft less than its full depth by almost the amount of its thickness, so that the portion projecting above the shaft and into the gear or other part is nearly square in section.

One great advantage of this form over a square ended key is the ease of placement or removal, a slight tapping on one end, caus-

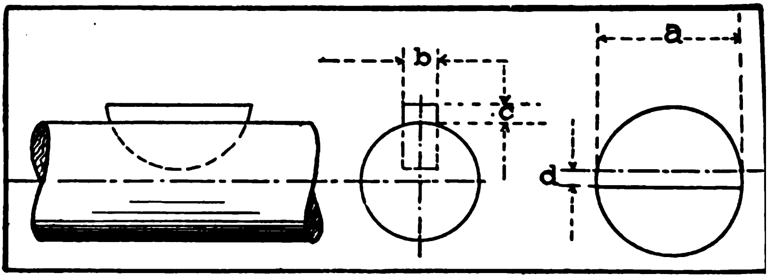


Fig. 476.—Diagram Showing Principal Dimensions of Woodruff Keys to Accompany Table of Sizes.

ing the semi-circular form to rise out of the other end of the ke seat, until it is loose enough to be picked out.

Nut Locking Means.—There is no mechanism in which it : more important to keep the nuts, bolts and other fastenings tigh than in the automobile, because these are operated at high speed over rough roads and are subjected to considerable vibration. A is well known vibration in machinery causes the various parts t loosen. While there are a number of methods of locking nuts an bolts to keep them from becoming loose, a practical method for us in automobile construction must be such that the nut can be re moved when desired without destroying the nut lock. For ex ample, it is possible to lock a nut securely by having the bolt little longer than is needed and by riveting the projecting end afte the nut is screwed in place. While this insures against loss of th nut it is apparent that when the nut is to be removed, it is fir necessary to chisel or file off the riveted portion of the bolt.

A large number of practical locking means for nuts and bolts shown at Fig. 477. The "Grip nut" which is shown at A is a plementary nut of peculiar form which is put on over the reg- · nut. These are blanked out of a bar of steel having an arch ning through the center and the nut is threaded through this ı. When it is screwed in place it is deflected by pressure so as produce a locking friction upon the thread. When screwed n tightly it is impossible for the nut to vibrate off though it r be easily removed with a wrench. Another device of similar n which is known as the "Hugtite" is shown at H. This looks a thin nut but instead of having threads there are two tongues ending from either side toward the center, engaging the bolt eads. These tongues are formed so that when the locking mem- is in place on the bolt its faces are not parallel to the face of nut as one edge touches the top of the nut and the other does . If the big nut tends to loosen from vibration it will bear inst the locking member and the friction produced between the gues and the bolt threads will prevent the main nut from com- off.

The castellated nut and cotter pin which is shown at C is so ely known and used that it requires no description. Lock hers have been devised in many forms, typical examples being wn at B, I, J and M. These for the most part are made of ing steel which must be flattened out when the nut is screwed n tightly. Some of these depend merely on spring pressure, ıgh others have barbs or ribs which are intended to dig into the and prevent it from coming loose. The ribbed washer is put place with the rib uppermost and when the nut is screwed down rib forces a small part of the metal from the nut into the ead and in this way locks the nut securely. The other forms ı as the "Positive," "National," and "Hobbs barbed" depend n the principle of one point digging into the nut and the other ı the metal the washer seats on. The "Columbia" lock nut is ery popular pattern and is virtually a double form. The nut per is split and tapered on the outside and fits into the hex- nal outer shell which is tapered inside as shown at E. Wher nut is screwed down tightly the inside part sliding on the

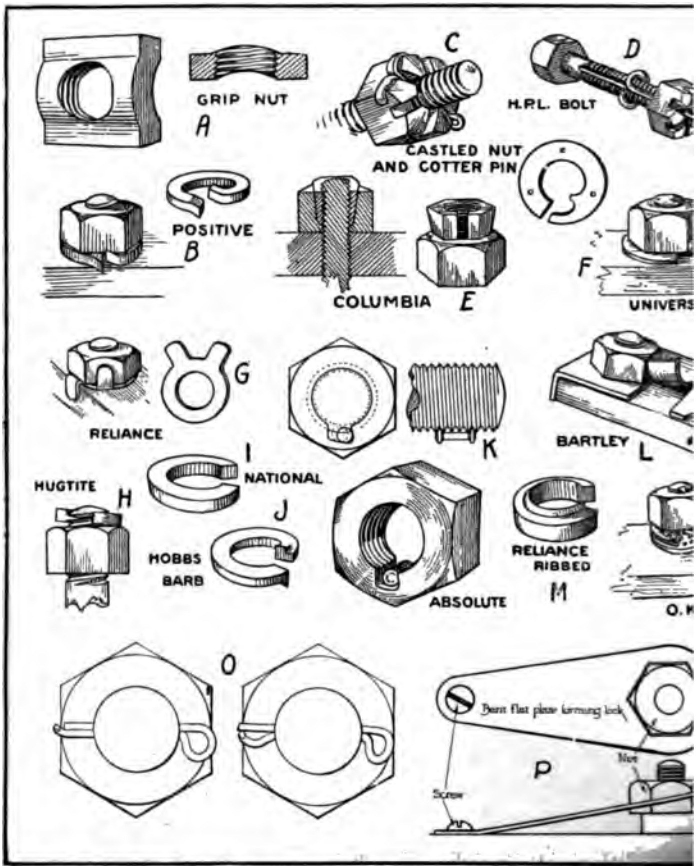


Fig. 477.—Nut Locking Means that Have Been Widely Us

draws the threaded portion together and forces the nut into a close contact with the th...s of the very good features of this lock ... at it ... with a wrench, yet absolutel...

Another form of lock ... "Absolute" and works ... properties of a rollin... surface of the nut ...

:h size that when the nut is screwed onto the bolt, the angle sides the locking pin heads fit into the threads of the bolt. The flat faces of the locking pin travel against the angle top of the re-s of the nut, rotating in its deepest portion. The top of the re-s is at such an angle that the nut is automatically and contin-usly locked against any backward motion which serves to wedge e pin more tightly in position. It is easy to take this nut off, as s can be accomplished by inserting a small brad or piece of wire o the recess to prevent the pin from rolling up into the small rt of the recess when the nut is unscrewed. This nut is more actical in the larger sizes than it is on the small size nuts widely ed in automobile construction.

Another system of locking depends upon preventing movement the nut after it has been screwed into place by a projecting igue bent up against the nut. As an example we have the "Uni-rsal" washer which is shown at F. This looks considerably like pring washer but differs in that it has a little tab or tongue that e nut rides over as it is screwed into place and when the nut is ht the tongue sticks up and prevents the nut from turning back. is washer is made of hardened steel and has projections on its der side to prevent it from turning. Another type of locking de-e that is very simple is the "Reliance," shown at G. This is thing more than a plain washer with a couple of tongues extend-g from the outer periphery which are bent against the nut and e piece the nut bears against, in the manner indicated. The Bartley" lock shown at L has been used for some time on rail-ads. This is nothing more than a plate which slips over the bolt sher and when the nut has been drawn up tongue which can be turned up against one ut to it from turning. The "O. K." er having the end formed to fit he nut and in a supplementary which is slotted. The corruga-nentary washer prevent the nut ewed down as tightly as is neces-ng washer.

somewhat on the principle of the

astellated nut and cotter pin is shown at B. In this method olt is slotted and a piece of strong and ductile wire is placed he slot, the lower end of which is formed into a washer to fit ween the nut and the surface through which the bolt is pass When the nut is drawn up tight the end of the wire, which nto the bolt slot is bent into one of the castellations of the The "Campbell Self-Locking" cotter pin which is shown at F 477, O, has been designed to replace the well-known spring cott This is of such form that it may be easily inserted in a hole when in place it can be locked by hitting the loop or eye with ammer which drives the short leg down, springing the bent nd forming a very effective lock. This cotter is made of ound stock, the same as the ordinary type, but has an offset nd the two limbs forming the body of the pin are of unequ ength. The pin may be easily removed when desired by insertin screw driver blade in the flattened eye and pulling the straig eg out of contact with the bent leg which makes it possible to with lraw the pin. A method of locking a nut which is sometimes used s shown at P. In this a bent plate having a hexagonal hole to fit he nut is held tightly at the other end by a screw threaded into he piece the nut retains or some other fixed part. This is seldom ised as it is more bulky and cumbersome than many of the simpler ock washers described.

Shop Uses of Arbor Press and Wheel Puller.—One of the use ul tools and one of the simplest included in the automobile repair hop equipment is an arbor press that can be adapted to a wide ariety of work. A form of press, especially devised for automobile epair shop work is shown at Fig. 478. This has sufficient height o that long pieces may be inserted between the ram and the bed while the supports are spaced sufficiently far apart to make it pos ible to insert relatively bulky articles. The press is adjustable as he bed plate may be moved up and down on the side rails in order o vary the opening between the movable member that exerts the ower and the work holding portion. The press is also suited for a ariety of machine shop operations. The view at A shows the nanner of forcing a driving gear off of the shaft of a roll. As vill be noted the bed is placed down near the base which make

ısible the introduction of the long roller. The gear to be forced is supported by two iron bars which rest on substantial wooden cks carried at either side of the roll. The pressure is exerted ıinst the end of the shaft, this forcing the shaft from the gear. e use of the press in straightening a bent rear axle housing is ›wn at B and on front axle work is shown at D. At C the opera-

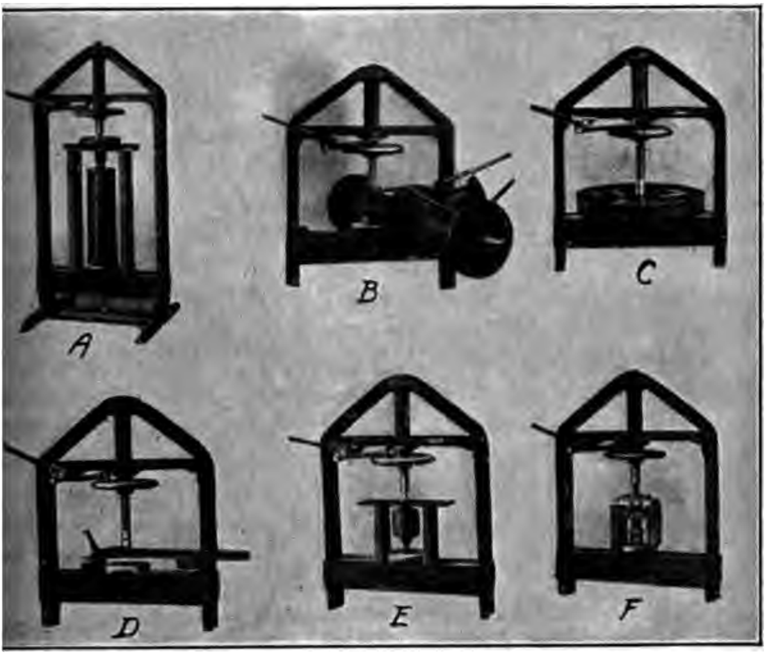


Fig. 478.—Uses of Arbor Press in Automobile Repair Shop.

ɔn of pressing in a bearing cup in a wheel hub is clearly shown. he manner in which relatively small parts may be handled is early outlined at E where a gear is being forced off of the armaıre shaft of a starting motor and at F where the constant mesh ıar is being removed from the countershaft of a gear set.

The wheel puller is also a very useful appliance, special forms ıited for repair shop work are shown at Fig. 479. The type ıown at A is a two armed puller having two sets of arms, the lo--

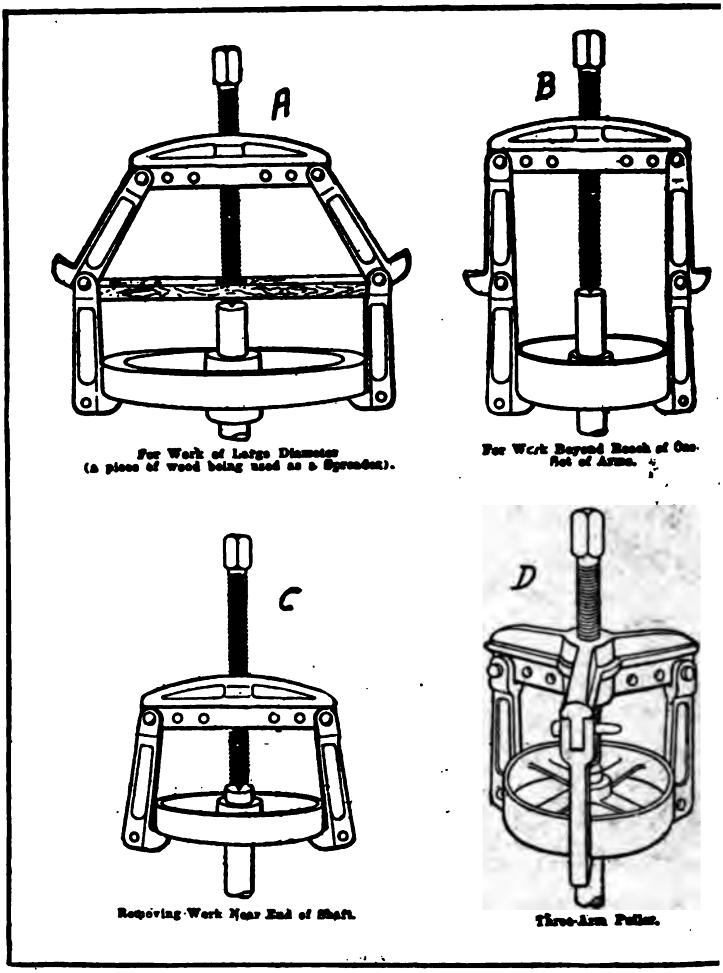


Fig. 479.—How to Use Wheel and Gear Pullers.

set being attached to the upper arm as indicated. This ma possible to handle work of relatively small diameter that is b reach of one set of arms as shown at B or on work of large dia that would be beyond the capacity or spread of the beam used as at A. In this case a piece of wood is being used as a sp

r the arms. It is relatively easy to move work near the end of .e shaft, this involving the use of only one set of arms as shown , C. The use of the three armed puller, which is a superior form r general service to that shown at C, inasmuch as it is not apt to ›ck over to one side or the other when the pressure is applied is ıown at D.

To Make Wood Acid Proof.—Some storage batteries are car- ed in wooden battery boxes on cars and annoy the owners by aking or slopping of the acid. To make the wood acid proof take x parts of wood tar and 12 parts resin, and melt them together ı an iron kettle, after which stir in eight parts of finely powdered ick dust. The surface to be covered must be thoroughly cleaned ıd dried before painting with the warm preparation.

Sharpening Files.—Lay dull and worn files in a solution of sul- huric acid, consisting of one part acid and two of water. Let ıem stand over night, then rinse in clear water. Put the acid in ı earthenware vessel. To resharpen old files wash them in warm ater to remove the grease and dirt, then rinse in warm water and ry by heat. Put $1\frac{1}{2}$ pints of warm water in a wooden vessel, put ı the files, add 3 oz. of blue vitriol, finely powdered, and 3 oz. of orax. Mix well and turn the files so that every one may come in ›ntact with the mixture. Add $10\frac{1}{2}$ oz. sulphuric acid and $\frac{1}{2}$ oz. f vinegar. Remove the files after a short time, dry, rub with olive il, wrap in porous paper. Coarse files should be kept in the mix- ıre for a longer time than the fine ones.

The Cheap Blackening of Brass.—The following solution for lackening brass is nothing new; in fact it has been known for a ıng time. Owing to its cheapness, ease in working and adapta- ility for many purposes, it has been deemed advisable to bring ; again to notice. Many platers of course will recognize it as an ld solution known to the plating industry for many years, but they ıay not have realized its advantages for some classes of work. The ›lution is made as follows:

Water	1 gallon
Sugar of lead	8 ounces
Hyposulphite of soda	8 ounces

The solution is used as hot as possible and the brass w simply dipped in it and allowed to remain until black. This about a minute or less. The articles are then rinsed in cold then in hot water and dried. If the pieces are scratch-br dry, the black deposit will have a high luster. When dippe the solution, the surface of the brass article becomes yellow, blue and finally black. The articles should always be lacq as the black deposit is likely to oxidize and fade if not; l coated with lacquer, it seems to be quite permanent. For a class of goods that require a black finish, this solution ca quently be used to a good advantage. It requires no electric rent used as a dip. The color, to be sure, is not a coal black resembles a graphite black more than anything else and l slight gray shade. It is sufficiently black, however, to answer purposes and it is so easily applied that it can be used on c goods with only a slight increase in cost.

Heat-Proof Paint.—To make a good cylinder exhaust paint, use two parts of black oxide of manganese, three par graphite and nine parts of Fuller's earth, thoroughly mixe which add a compound of 10 quarts of sodium silicate, one of glucose and four parts of water, until it is of such consist that it may be applied with a brush.

Etching.—To etch iron or steel mix one-half ounce of n and one ounce muriatic acid. Shake well, and it is ready for Cover the place to be etched with melted beeswax and wher write the inscription plainly in the wax clear to the metal wi sharp instrument; then apply the mixture with a feather, fully filling each letter. Let remain from one to ten mini then throw on water, which stops the etching process, and re the wax.

Use of Tools.—Never use a tap in a cored or rough hole. a heavy flat drill through to take out scale, sand or project Use plenty of good lard oil in cutting threads with a die. times a die tap is ruined the first time it is used, because was no oil put on the work. Never use taps in any metal wi using plenty of good oil. The tap will gauld in any metal tear the threads off unless well oiled. Never draw a monkey w

ard from the jaws. Always pull toward the jaws, otherwise ar may be bent. Never use a reamer on pipe of any kind. cale inside of the pipe, caused by the flux used in welding azing, is as hard as glass and no reamer made is hard enough t it.

rilling Holes in Glass.—Holes of any desired size may be d in glass by the following method: Take a small three-cor- file and grind the points from one corner on the bias from the and set it in a brace, such as employed in boring wood, etc. he glass in which the holes are to be bored on a smooth sur- covered with a blanket or some other similar material, and to bore the hole. When a slight impression is made on the place a disc of putty around it and fill with turpentine to nt heating by friction. Continue boring the hole, but do not too hard on the brace when drilling.

aking a Magnet of a File.—Small nuts or washers or other parts, which have fallen into the crankcase may often be re- d without the necessity of dismantling the engine by means magnet. By taking about a dozen turns of one strand of the to which a lighted electric lamp is attached around a file ll be magnetized quite strongly enough for all practical oses.

eculiar Case of Knocking.—The car was a popular four-cylin- iodel about a year old. It was brought to the shop for a thor- overhauling, and for taking up all the bearings. When the job complete and the engine operated, a very severe knock de- ed that sounded exactly like a loose bearing. After consider- experimenting, it was found that one of the pistons touched ulder in the top of the cylinder, this was because the packing een the cylinder and crankcase had been reduced in thickness le. A thicker packing cured the trouble.

ust on Tools and Work.—Vaseline, to which has been added all amount of powdered gum camphor, heated over a slow fire, prevent rust on tools. A mixture of one pound of lard, one e of gum camphor and a little lampblack melted together will ct bright work from rust. Other formulæ are: A mixture of and kerosene in equal parts, a mixture of tallow and white

lead, and of tallow and lime. Smear the parts to be protected any one of these mixtures.

Screw Cutting Gears.—Multiply the number of threads c equal gears, as indicated on the index, by the number that will for a product a gear on the index. Place this gear on the sp or stud. Multiply the number of threads per inch to be cut b same number and put the resulting gear on the screw. Thus, lathe cuts four threads by equal gears and 13 threads per inc wanted then multiply by five, showing that to cut 13 threads inch would require a gear of 20 teeth on the spindle or stud a gear of 65 on the lead screw.

Treating Polished Iron or Steel.—Wash polished iron or that has become gray and lusterless, with a stiff brush and amm soapsuds. Rinse well and dry by heat if possible. Then app plentiful supply of sweet oil and dust thickly with powdered q lime. Let the lime stay on two days, after which it shoul cleaned off with a stiff brush. Polish with a softer brush and with cloths until the luster comes out. By leaving the lime on, and steel may be kept from rust almost indefinitely.

Speed of Grindstones.—To grind machinist's tools stones sh have a speed of about 800 feet a minute at periphery, a 30 stone running about 100 revolutions a minute. In grinding penter's tools a speed of 600 feet a minute at periphery shoul maintained, a 30 inch stone running 75 revolutions a minute.

Cleaning Brass Castings.—Brass castings that are greasy be cleaned by boiling in lye or potash. The first pickle is comp of one quart of nitric acid, and six to eight quarts of water. A washing in clear warm or hot water the casting should be imme in the second pickle, composed of one quart of sulphuric acid, quarts of nitric acid and a few drops of muriatic acid.

Laying Out Work.—Use blue vitriol and water on the sur of steel or iron in laying out work. This will give a nice cop plate surface, so that all lines will show plainly. A little o vitriol will eat off oily surfaces and leave them nicely copper

Pipe Joint Cement.—Mix 10 parts of iron filings and t parts of chloride of lime to a paste by means of water. App the joint and clamp. It will be solid in 12 hours.

Drilling.—Use kerosene to drill, ream or turn malleable iron, to drill or turn aluminum. Turpentine should be used instead oil for drilling hard steel, as it will cause drilling readily when e metal cannot be touched with oil. By using a combination of rpentine and camphor, glass may be drilled with a common drill. hen the point of the drill comes through the hole should be rked with the end of a three-cornered file, having edges ground arp. Use the corners of the file to scrape rather than as a reamer. eat care must be taken not to crack the glass or flake off pieces it while finishing. The mixture should be used freely, both while illing and scraping. It may be used as well to drill hard cast n and tempered steel.

Body Polish.—A much recommended body polish is made by ixing the following ingredients:

Turpentine	1 gallon
Paraffine Oil	1 pint
Oil of Citronella	3½ ounces
Oil of Cedar	1½ ounces

Another scheme is to use a mixture of boiled linseed oil and rpentine, applying it sparingly and rubbing absolutely dry. The e of these polishes will restore even an old car to a degree of ightness that will please the owner. Floor wax is also used, as furniture polish.

Care of Tops.—Mohair tops should be frequently dusted and ushed off. Pantasote tops and curtains are best cleaned with a ft brush dipped in water to which a little ammonia has been ded. Afterwards rub dry. Never attempt to clean top and curins with gasoline or kerosene. Do not fold the top until it has come thoroughly dry, because any moisture remaining in the lds is apt to cause mildew, besides making the top leaky and unghtly with spots. When a car is not used for some time, it is st to open the top, which keeps it well stretched and smooth.

Care of Leather Upholstery.—Do not use gasoline in cleaning ather upholstery. Plain water with a little ammonia will remove e dirt and a brisk rubbing with a clean woolen or flannel cloth

will do the rest. For still more careful treatment use a r leather dressing.

Care of Cloth Upholstery.—Do not use an acid soluti cleaning cloth upholstery.

Cloth is not affected by climatic conditions and withstand heat and cold, and having no oil in its make-up, does not pi or hold dust readily. To remove ordinary dust, beat cushior backs lightly with stick or carpet beater, then remove dust whisk-broom or brush. Grease or oil may be removed by the cation of a solution of luke warm water and Ivory soap a with a woolen cloth. Any of the approved methods for cle woolen cloth may be used with success on this upholstery. line and benzine have a tendency to spread instead of removi dirt. Their use is not recommended for this reason, although work no injury to the fabric.

CHAPTER XIV

USEFUL TABLES FOR THE MECHANIC.

Mathematical Tables

le of Inch Decimal Equivalents—Millimeter Decimal Equivalents—Metric Conversion Tables—General Formulæ in Mensuration—Diagonals of Hexagons and Squares—U. S. Measures and Weights—Trigonometrical Formulæ—Circumferences and Areas of Circles.

Mechanical Tables

A. E. Screw Standard—Standard Hexagon Bolts and Nuts—Machine Screw Table—Dimensions—Pipe Threads—S. A. E. Carburetor Fittings—Standards for Wire Gauges—Calculating Length of Chain—Table of Allowances for Grinding—Sizes of Drills to Use for Hand Taps—Twist Drill Gauge Sizes Speed of Drills—Figuring Emery Wheel Speeds—Pulley Sizes—Lathe Gearing for Cutting Threads—Allowances for Fits.

Miscellaneous Tables

ne Per Mile Expressed in Miles Per Hour—Comparative Scale, Fahrenheit and Centigrade Thermometers—Horsepower Chart—Compression Pressure—Approximate Horsepower of Four-Cycle Engines—Two-Cycle Engines—Indicated Horsepower—Weights of Metals—Weight of Steel Bars—Weight of Castings to That of Wood Patterns—Table of Gradients—Calculating Grade Percentages—Chart for Determining Speed of Car.

THOSE engaged in mechanical work cannot fail to appreciate the les which follow, selected with care and with special reference automobile repairing, machine work and allied industries. These ve been compiled from standard authorities on mechanics, standls, metallurgy, automobile construction and design, mathematics, cetera, and therefore can be divided into three general classes. ose dealing with arithmetic are in one group, those having to do th machine work are in another group, while the remainder deal th miscellaneous subjects. It is believed that the tabulation can of value in many ways to the motorist as well as to the mechanic. hile this data is available to all who can consult different standard rks, it is believed that compilation in condensed form, as well as rearrangement in some cases to simplify the matter, will make it

of real service to the laymen as well as the more expert mach
and repairman. Because of the number of authorities consulted
the many works from which the tables have been made, it is
possible to give individual acknowledgment, especially as man
the tabulations have long been public property and have been
erally used by writers on mechanical subjects.

Table of Decimal Equivalents

8ths	$\frac{7}{32}$ = .21875	$\frac{19}{64}$ = .296875
$\frac{1}{8}$ = .125	$\frac{9}{32}$ = .28125	$\frac{21}{64}$ = .328125
$\frac{1}{4}$ = .250	$\frac{11}{32}$ = .34375	$\frac{23}{64}$ = .359375
$\frac{3}{8}$ = .375	$\frac{13}{32}$ = .40625	$\frac{25}{64}$ = .390625
$\frac{1}{2}$ = .500	$\frac{15}{32}$ = .46875	$\frac{27}{64}$ = .421875
$\frac{5}{8}$ = .625	$\frac{17}{32}$ = .53125	$\frac{29}{64}$ = .453125
$\frac{3}{4}$ = .750	$\frac{19}{32}$ = .59375	$\frac{31}{64}$ = .484375
$\frac{7}{8}$ = .875	$\frac{21}{32}$ = .65625	$\frac{33}{64}$ = .515625
	$\frac{23}{32}$ = .71875	$\frac{35}{64}$ = .546875
16ths	$\frac{25}{32}$ = .78125	$\frac{37}{64}$ = .578125
$\frac{1}{16}$ = .0625	$\frac{27}{32}$ = .84375	$\frac{39}{64}$ = .609375
$\frac{3}{16}$ = .1875	$\frac{29}{32}$ = .90625	$\frac{41}{64}$ = .640625
$\frac{5}{16}$ = .3125	$\frac{31}{32}$ = .96875	$\frac{43}{64}$ = .671875
$\frac{7}{16}$ = .4375	64ths	$\frac{45}{64}$ = .703125
$\frac{9}{16}$ = .5625	$\frac{1}{64}$ = .015625	$\frac{47}{64}$ = .734375
$\frac{11}{16}$ = .6875	$\frac{3}{64}$ = .046875	$\frac{49}{64}$ = .765625
$\frac{13}{16}$ = .8125	$\frac{5}{64}$ = .078125	$\frac{51}{64}$ = .796875
$\frac{15}{16}$ = .9375	$\frac{7}{64}$ = .109375	$\frac{53}{64}$ = .828125
	$\frac{9}{64}$ = .140625	$\frac{55}{64}$ = .859375
32ds	$\frac{11}{64}$ = .171875	$\frac{57}{64}$ = .890625
$\frac{1}{32}$ = .03125	$\frac{13}{64}$ = .203125	$\frac{59}{64}$ = .921875
$\frac{3}{32}$ = .09375	$\frac{15}{64}$ = .234375	$\frac{61}{64}$ = .953125
$\frac{5}{32}$ = .15625	$\frac{17}{64}$ = .265625	$\frac{63}{64}$ = .984375

ble of Decimal Equivalents of Millimeters and Fractions of Millimeters

Mm.	Inches	Mm.	Inches	Mm.	Inches
$\frac{1}{50}$ =	.00079	$\frac{26}{50}$ =	.02047	2 =	07874
$\frac{2}{50}$ =	00157	$\frac{27}{50}$ =	.02126	3 =	.11811
$\frac{3}{50}$ =	.00236	$\frac{28}{50}$ =	02205	4 =	.15748
$\frac{4}{50}$ =	.00315	$\frac{29}{50}$ =	.02283	5 =	.19685
$\frac{5}{50}$ =	.00394	$\frac{30}{50}$ =	.02362	6 =	.23622
$\frac{6}{50}$ =	.00472	$\frac{31}{50}$ =	.02441	7 =	.27559
$\frac{7}{50}$ =	.00551	$\frac{32}{50}$ =	.02520	8 =	.31496
$\frac{8}{50}$ =	.00630	$\frac{33}{50}$ =	.02598	9 =	.35433
$\frac{9}{50}$ =	.00709	$\frac{34}{50}$ =	.02677	10 =	.39370
$\frac{10}{50}$ =	.00787	$\frac{35}{50}$ =	.02756	11 =	.43307
$\frac{11}{50}$ =	.00866	$\frac{36}{50}$ =	.02835	12 =	.47244
$\frac{12}{50}$ =	.00945	$\frac{37}{50}$ =	.02913	13 =	.51181
$\frac{13}{50}$ =	.01024	$\frac{38}{50}$ =	.02992	14 =	.55118
$\frac{14}{50}$ =	.01102	$\frac{39}{50}$ =	.03071	15 =	.59055
$\frac{15}{50}$ =	.01181	$\frac{40}{50}$ =	.03150	16 =	.62992
$\frac{16}{50}$ =	.01260	$\frac{41}{50}$ =	.03228	17 =	.66929
$\frac{17}{50}$ =	.01339	$\frac{42}{50}$ =	.03307	18 =	.70866
$\frac{18}{50}$ =	01417	$\frac{43}{50}$ =	.03386	19 =	.74803
$\frac{19}{50}$ =	.01496	$\frac{44}{50}$ =	.03465	20 =	.78740
$\frac{20}{50}$ =	.01575	$\frac{45}{50}$ =	.03543	21 =	.82677
$\frac{21}{50}$ =	.01654	$\frac{46}{50}$ =	.03622	22 =	.86614
$\frac{22}{50}$ =	.01732	$\frac{47}{50}$ =	.03701	23 =	.90551
$\frac{23}{50}$ =	.01811	$\frac{48}{50}$ =	.03780	24 =	.94488
$\frac{24}{50}$ =	.01890	$\frac{49}{50}$ =	.03858	25 =	.98425
$\frac{25}{50}$ =	.01969	1 =	.03937	26 =	1.02362

10 mm. = 1 Centimeter = 0.3937 inches.
10 cm. = 1 Decimer = 3.937 inches.
10 dm. = 1 Meter = 39.37 inches.
25.4 mm. = 1 English inch.

Metric System and English Equivalents.

The Metric System is based on the Meter which was designed to be one ten-millionth ($\frac{1}{10000000}$) part of the earth's meridian, passing through Dunkirk and Formentera. Later investigations, however, have shown that the Meter exceeds one ten-millionth part by almost one part in 6400. The value of the Meter, as authorized by the U. S. Government is 39.37 inches. The Metric system was legalized by the U. S. Government in 1866.

The three principal units are the meter, the unit of length, the liter, the unit of capacity, and the gram, the unit of weight. Multiples of these are obtained by prefixing the Greek words: deka (10), hekto (100), and kilo (1000). Divisions are obtained by prefixing the Latin words: deci ($\frac{1}{10}$), centi ($\frac{1}{100}$), and milli ($\frac{1}{1000}$). Abbreviations of the multiples begin with a capital letter, and of the divisions with a small letter, as in the following tables:

Measures of Length

10 millimeters (mm.) .... = 1 centimeter (cm.) .... = .3937 in.
10 centimeters .... = 1 decimeter (dm.)
10 decimeters .... = 1 meter (m.) .... = 3.28083 ft. = 39.37 ins.
10 meters .... = 1 dekameter (Dm.)
10 dekameters .... = 1 hektometer (Hm.)
10 hektometers .... = 1 kilometer (Km.) .... = 0.62137 mile

1 foot .... = .3048 meter
1 inch .... = 25.4 millimeters

Measures of Surface (not Land)

100 square millimeters ($mm.^2$) .... = 1 square centimeter ($cm.^2$) = 0.155 sq. in.
100 square centimeters .... = 1 square decimeter ($dm.^2$)
100 square decimeters .... = 1 square meter ($m.^2$) .... = 10.764 sq. ft.

1 square yard .... = .836 square meter
1 square foot .... = .0929 square meter
1 square inch .... = 645.2 square millimeters

Measures of Volume

1000 cubic millimeters ($mm.^3$) = 1 cubic centimeter ($cm.^3$) .... = .061 cu. in.
1000 cubic centimeters .... = 1 cubic decimeter ($dm.^3$) = 1 liter = 61.023 cu. ins.
1000 cubic decimeters .... = 1 cubic meter ($m.^3$) = 35.314 cu. ft. = 264.2 gallons

1 cubic yard .... = .7645 cubic meter
1 cubic foot .... = .02832 cubic meter
1 cubic inch .... = 16.387 cubic centimeters

Measures of Capacity

10 milliliters (ml.) .... = 1 centiliter (cl.)
10 centiliters .... = 1 deciliter (dl.)
10 deciliters .... = 1 liter (l.) = 1.0567 qts. (U.S.) = 61.023 cu. ins.
10 liters .... = 1 dekaliter (Dl.)
10 dekaliters .... = 1 hektoliter (Hl.)
10 hektoliter .... = 1 kiloliter (Kl.)

1 gallon (U.S.) .... = 3.785 liters
1 gallon (British) .... = 4.543 liters

Measures of Weight

10 milligrams (mg.) .... = 1 centigram (cg.)
10 centigrams .... = 1 decigram (dg.)
10 decigrams .... = 1 gram (g.) .... = 15.432 grains
10 grams .... = 1 dekagram (Dg.)
10 dekagrams .... = 1 hektogram (Hg.)
10 hektograms .... = 1 kilogram (Kg.) .... = 2.2046 pounds
1000 kilograms .... = 1 ton (T) .... = .9842 ton of 2240 pounds

NOTE—The gram is the weight of one cubic centimeter of pure distilled water at a temperature of 39.2°F.; the kilogram is the weight of 1 liter of water; the ton is the weight of 1 cubic meter of water.

1 grain .... .0648 gram
1 ounce (Avd.) .... = 28.35 grams
1 pound = .4536 kilograms
1 ton of 2240 pounds = 1.016 metric tons

General Formulæ.

ircumference — diameter x 3.1416, nearly; more accurately 3.141592

pproximations, $\frac{22}{7}$ — 3.143; $\frac{355}{113}$ — 3.141592; $\frac{1}{3.141592}$ — .3183

)iameter — circumference x .3183.

)iameter of circle x .88623 } — side of equal square.
ircumference of circle x .28209 }

'ircumference of circle x 1.1284 — perimeter of equal square.

)iameter of circle x .7071 } — side of inscribed square.
'ircumference of circle x .22508 }

ide of square x 1.4142 — diameter of circumscribed circle.
" " x 4.4428 — circum. " " "
" " x 1.1284 — diameter of equal circle.
" " x 3.5449 — circum. " " "

'erimeter of square x .88623 — circumference of equal circle.

Areas

rea of triangle — base x ½ perpendicular height.

rea of parallelogram — base x perpendicular height.

rea of trapezoid — half the sum of the parallel sides x perpendicular height.

rea of circle — diameter squared x .7854 nearly, more accurately .7853982.

rea of circle x .63662 — area of inscribed square.

rea of circular ring — sum of the two diameters x difference of the two diameters, and the product x .7854.

rea of parabola — base x ⅔ height.

rea of pyramid or cone — circumference or periphery of base x ½ slant height.

rea of ellipse — long diameter x short diameter x .7854.

Surfaces

urface of cylinder — area of both ends + (length x circumference.)

urface of sphere — diameter squared x 3.1416, or circumference x diameter.

Solid Contents

ontents of prism, right or oblique — area of base x perpendicular height.

ontents of cylinder — area of end x perpendicular height.

ontents of sphere — diameter cubed x .5236, or surface x ⅙ diam.

ontents of pyramid or cone — area of base x ⅓ perpendicular h'g't.

Diagonals of Hexagons and Squares

Across Flats	Across Corners		Across Flats	Across Corners		Across Flats	Across Corners	
	Hexagon	Squares		Hexagon	Squares		Hexagon	Squares
1/16	.072	.088	1 3/8	1.587	1.944	2 11/16	3.103	[illegible]
1/8	.144	.177	1 7/16	1.659	2.032	2 3/4	3.175	[illegible]
3/16	.216	.265	1 1/2	1.732	2.121	2 13/16	3.247	[illegible]
1/4	.288	.353	1 9/16	1.804	2.209	2 7/8	3.319	4.065
5/16	.360	.441	1 5/8	1.876	2.298	2 15/16	3.391	4.154
3/8	.432	.530	1 11/16	1.948	2.386	3	3.464	4.242
7/16	.505	.618	1 3/4	2.020	2.470	3 1/16	3.536	4.331
1/2	.577	.707	1 13/16	2.092	2.563	3 1/8	3.608	4.419
9/16	.649	.795	1 7/8	2.165	2.651	3 3/16	3.680	4.507
5/8	.721	.883	1 15/16	2.237	2.740	3 1/4	3.752	4.596
11/16	.793	.972	2	2.309	2.828	3 5/16	3.824	4.684
3/4	.865	1.060	2 1/16	2.381	2.916	3 3/8	3.897	4.772
13/16	.938	1.149	2 1/8	2.453	3.005	3 1/2	4.041	4.949
7/8	1.010	1.237	2 3/16	2.525	3.093	3 5/8	4.185	5.126
15/16	1.082	1.325	2 1/4	2.598	3.182	3 3/4	4.330	5.303
1	1.155	1.414	2 5/16	2.670	3.270	3 7/8	4.474	5.480
1 1/16	1.226	1.502	2 3/8	2.742	3.358	4	4.618	5.656
1 1/8	1.299	1.591	2 7/16	2.814	3.447	4 1/8	4.763	5.833
1 3/16	1.371	1.679	2 1/2	2.886	3.535	4 1/4	4.904	6.010
1 1/4	1.443	1.767	2 9/16	2.958	3.623	4 3/8	5.051	6.187
1 5/16	1.515	1.856	2 5/8	3.031	3.712	4 1/2	5.196	[illegible]

Diagonal of hexagon equals 1.155 times distance across flats.
Diagonal of square equals 1.414 times distance across flats.

AREAS OF SMALL CIRCLES UP TO ONE INCH

DIA.	0	.1	.2	.3	.4	.5	.6	.7	.8	
Inc.	AREAS									
.00	.0	.0078	.0314	.0706	.1256	.1963	.2827	.3848	.5026	.6
.01	.000078	.0095	.03464	.0755	.132	.2043	.2922	.3959	.5153	.6
.02	.00031	.0113	.038	.0804	.1385	.2124	.3014	.4071	.5281	.6
.03	.0007	.0133	.0415	.0855	.1452	.2206	.3117	.4185	.5411	.6
.04	.00125	.0154	.0452	.0908	.1520	.2290	.3217	.4301	.5542	.6
.05	.00196	.0177	.0491	.0962	.1590	.2376	.3318	.4418	.5674	.7
.06	.00283	.0201	.0531	.1018	.1662	.2463	.3421	.4536	.5809	.7
.07	.00385	.0227	.0572	.1075	.1735	.2552	.3526	.4657	.5945	.7
.08	.00503	.0255	.0616	.1134	.181	.2642	.3632	.4778	.6082	.7
.09	.00638	.0283	.066	.1195	.1886	.2734	.3739	.4902	.6221	.7

Across the top are the diameters of circles, and at the left are placed increments increasing by 01 of an inch. Thus the area of a circle .55 o inch in diameter, .2376 of a square inch, will be found under .5 and opposite

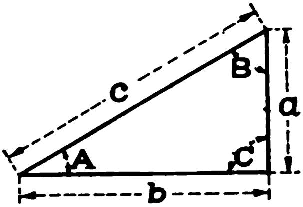
[redacted]

CIRCUMFERENCES AND AREAS OF CIRCLES

From 1 inch to 25 inches inclusive

Circum.	Area	Diam.	Circum.	Area	Diam.	Circum.	Area
3.1416	.7854	4	12.566	12.566	8	25.133	50.265
3.3379	.8866	1/16	12.763	12.962	1/8	25.525	51.849
3.5343	.9940	1/8	12.959	13.364	1/4	25.918	53.546
3.7306	1.1075	3/16	13.155	13.772	3/8	26.311	55.088
3.9270	1.2272	1/4	13.352	14.186	1/2	26.704	56.745
4.1233	1.3530	5/16	13.548	14.607	5/8	27.096	58.426
4.3197	1.4849	3/8	13.744	15.033	3/4	27.489	60.132
4.5160	1.6230	7/16	13.941	15.466	7/8	27.882	61.862
4.7124	1.7671	1/2	14.137	15.904			
4.9087	1.9175	9/16	14.334	16.349	9	28.274	63.617
5.1051	2.0739	5/8	14.530	16.800	1/8	28.667	65.397
5.3014	2.2365	11/16	14.726	17.257	1/4	29.060	67.201
5.4978	2.4053	3/4	14.923	17.728	3/8	29.452	69.029
5.6941	2.5802	13/16	15.119	18.190	1/2	29.845	70.882
5.8905	2.7612	7/8	15.315	18.665	5/8	30.238	72.760
6.0868	2.9483	15/16	15.512	19.147	3/4	30.631	74.662
					7/8	31.023	76.589
6.2832	3.1416	5	15.708	19.635			
6.4795	3.3410	1/16	15.904	20.129	10	31.416	78.540
6.6759	3.5466	1/8	16.101	20.629	1/8	31.809	80.516
6.8722	3.7583	3/16	16.297	21.135	1/4	32.201	82.516
7.0686	3.9761	1/4	16.493	21.648	3/8	32.594	84.541
7.2649	4.2000	5/16	16.690	22.166	1/2	32.987	86.500
7.4613	4.4301	3/8	16.886	22.691	5/8	33.379	88.664
7.6576	4.6664	7/16	17.082	23.221	3/4	33.772	90.763
7.8540	4.9087	1/2	17.279	23.758	7/8	34.165	92.886
8.0503	5.1572	9/16	17.475	24.301			
8.2467	5.4119	5/8	17.671	24.850	11	34.558	95.033
8.4430	5.6727	11/16	17.868	25.406	1/8	34.950	97.205
8.6394	5.9396	3/4	18.064	25.967	1/4	35.343	99.402
8.8357	6.2126	13/16	18.261	26.535	3/8	35.736	101.62
9.0321	6.4918	7/8	18.457	27.109	1/2	36.128	103.87
9.2284	6.7771	15/16	18.653	27.688	5/8	36.521	106.14
					3/4	36.914	108.43
9.4248	7.0686	6	18.850	28.274	7/8	37.306	110.75
9.6211	7.3662	1/8	19.242	29.465			
9.8175	7.6699	1/4	19.635	30.680	12	37.699	113.10
10.014	7.9798	3/8	20.028	31.919	13	40.841	132.73
10.210	8.2958	1/2	20.420	33.183	14	43.982	153.94
10.407	8.6179	5/8	20.813	34.472	15	47.124	176.71
10.603	8.9462	3/4	21.206	35.785	16	50.265	201.06
10.799	9.2806	7/8	21.598	37.122	17	53.407	226.98
10.996	9.6211				18	56.549	254.47
11.192	9.9678	7	21.991	38.485	19	59.600	283.53
11.388	10.321	1/8	22.384	39.871	20	62.832	314.16
11.585	10.680	1/4	22.776	41.282	21	65.973	346.36
11.781	11.045	3/8	23.169	42.718	22	69.115	380.13
11.977	11.416	1/2	23.562	44.197	23	72.257	415.48
12.174	11.793	5/8	23.955	45.664	24	75.398	452.39
12.370	12.177	3/4	24.347	47.173	25	78.540	490.87
		7/8	24.740	48.707			

Trigonometrical Formulæ, Etc.



Geometrical Solution of Right-Angled Triangles

$$c = \sqrt{a^2 + b^2}$$

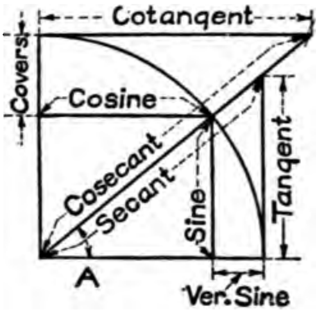
$$b = \sqrt{c^2 - a^2}$$

$$a = \sqrt{c^2 - b^2}$$

$$\text{sin. A.} = \frac{a}{c} = \frac{\text{opposite side}}{\text{hypotenuse}} \qquad \text{cos. A.} = \frac{b}{c} = \frac{\text{adjacent side}}{\text{hypotenuse}}$$

$$\text{tan. A.} = \frac{a}{b} = \frac{\text{opposite side}}{\text{adjacent side}} \qquad \text{cot. A.} = \frac{b}{a} = \frac{\text{adjacent side}}{\text{opposite side}}$$

$$\text{sec. A.} = \frac{c}{b} = \frac{\text{hypotenuse}}{\text{adjacent side}} \qquad \text{cosec. A.} = \frac{c}{a} = \frac{\text{hypotenuse}}{\text{opposite side}}$$



General Equivalents

The illustration shows the different trigonometrical expressions in terms of the angle A.

In the following formulæ the radius = 1.

Complement of an angle = its difference from 90°.
Supplement of an angle = its difference from 180°.

$$\text{Sin.} = \frac{1}{\text{cosec.}} = \frac{\text{cos.}}{\text{cot.}} = \sqrt{(1 - \text{cos.}^2)}$$

$$\text{Cos.} = \sqrt{(1 - \text{sin.}^2)} = \frac{\text{sin.}}{\text{tan.}} = \text{sin. x cot.} = \frac{1}{\text{sec.}}$$

$$\text{Sec.} = \sqrt{\text{rad.}^2 + \text{tan.}^2} = \frac{1}{\text{cos.}} = \frac{\text{tan.}}{\text{sin.}} \qquad \text{Cosec} = \frac{1}{\text{sin.}}$$

$$\text{Tan.} = \frac{\text{sin.}}{\text{cos.}} = \frac{1}{\text{cot.}} \qquad \text{Cot.} = \frac{\text{cos.}}{\text{sin.}} = \frac{1}{\text{tan.}}$$

$$\text{Versin.} = \text{rad.} - \text{cos.} \qquad \text{Coversin.} = \text{rad.} - \text{sin.}$$

$$\text{Rad.} = \text{tan. x cot.} = \sqrt{\text{sin.}^2 + \text{cos.}^2}$$

[redacted]

U. S. Measures and Weights

DRY MEASURE.—U. S.

2 pints = 1 quart. 8 quarts = 1 peck. 4 pecks = 1 bushel.
standard U. S. bushel is in cylinder form, 18½ inches diameter and 8 nches deep, and contains 2150.42 cubic inches.
uck bushel = 2150.42 cubic inches, or 1.2445 cubic feet.
aped bushel = 1¼ struck bushels.

SHIPPING MEASURE.

100 cubic feet = 1 register ton.

40 cubic feet = 1 U. S. shipping ton; 31.16 Imperial bushels; 32.143 U. S. bushels.

42 cubic feet = 1 British shipping ton; 32.719 Imperial bushels; 33.75 U. S. bushels.

EASURES OF WEIGHT.—Avoirdupois or Commercial Weight.

achms, or 437.5 grains = 1 ounce, oz.
nces, or 7,000 grains = 1 pound, lb.
unds = 1 quarter, qr.
arters = 1 hundred-weight, cwt. = 112 lbs.
ndred-weight = 1 ton of 2240 pounds, or long ton.
pounds = 1 net, or short ton.
8 pounds = 1 metric ton.
ne = 14 pounds. 1 quintal = 100 pounds.

TROY WEIGHT.

24 grains = 1 pennyweight, dwt.
20 pennyweights = 1 ounce, oz. = 480 grains.
12 ounces = 1 pound, lb. = 5760 grains.

APOTHECARIES' WEIGHT.

20 grains = 1 scruple.
3 scruple = 1 drachm = 60 grains.
8 drachms = 1 ounce = 480 grains.
12 ounces = 1 pound = 5760 grains.

CIRCULAR MEASURE.

60 seconds ″ = 1 minute ′.
60 minutes ′ = 1 degree °.
90 degrees = 1 quadrant.
360 degrees = 1 circumference.

TIME.

60 seconds = 1 minute.
60 minutes = 1 hour.
24 hours = 1 day.
7 days = 1 week.
365 days, 5 hours, 48 minutes, 48 seconds = 1 year.

BOARD MEASURE.

number of feet, board measure (B. M.) = length in feet x breadth in feet x thickness in inches.

S. gallon=8.33 pounds. 1 cubic foot of water at 39.1°F=62.425 lbs.
glish gallon=10 pounds. 1 cubic inch of water at 39.1°F=.036 lbs.
ic foot of ice=57.2 pounds. 1 pound of water=27,72 cubic inches.
1 ton of water=35.90 cubic feet.

U. S. Measures and Weights

Continued

LONG MEASURE.—Measures of Length.

12 inches = 1 foot.
3 feet, or 36 inches = 1 yard.
5½ yards, or 16½ feet = 1 rod, pole, or perch.
40 rods, or 220 yards = 1 furlong.
8 furlongs, or 320 rods, or 1,760 yards or 5,280 feet = 1 mile.
3 miles = 1 league.

Additional Measures of Length.

1,000 mils = 1 inch. 4 inches = 1 hand. 9 inches = 1 span.,
2½ feet = 1 military pace. 2 yards = 1 fathom.

SQUARE MEASURE.—Measures of Surface.

144 square inches, or 183.35 circular inches = 1 square foot.
9 square feet = 1 square yard.
30¼ square yards, or 272¼ square feet = 1 square rod, pole, or perch.
160 square rods = 1 acre.
640 acres = 1 square mile
An acre equals a square whose side is 208.71 feet.
A circular inch is the area of a circle 1 inch in diameter = 0.785398 sq. inches.
1 square inch = 1.2732 circular inches.
A circular mil is the area of a circle 1 mil or .001 in diameter. The mil is used in electrical calculations.

SOLID OR CUBIC MEASURES.—Measures of Volume.

1728 cubic inches = 1 cubic foot.
27 cubic feet = 1 cubic yard.
1 cord of wood = a pile, 4 x 4 x 8 feet = 128 cubic feet.
1 perch of masonry = 16½ x 1½ x 1 foot = 24¾ cubic feet.

LIQUID MEASURE.

4 gills = 1 pint.
2 pints = 1 quart.
4 quarts = 1 gallon { U. S. 231 cubic inches. / English 277.274 cubic inches.
31½ gallons = 1 barrel.
42 gallons = 1 tierce.
2 barrels or 63 gallons = 1 hogshead.
84 gallons or 2 tierces = 1 puncheon.
2 hogshead or 126 gallons = 1 pipe or butt.
2 pipes or 3 puncheons = 1 tun.
7 4805 U. S. gallons = 1 cubic foot.
1 British Imperial gallon = 1.20032 U. S. gallons.

APOTHECARIES' FLUID MEASURE.

60 minims = 1 fluid drachm.
8 drachms, or 437½ grains, or 1,782 cubic inches = 1 fluid ounce.

Water is at its greatest density at 39.2°F.

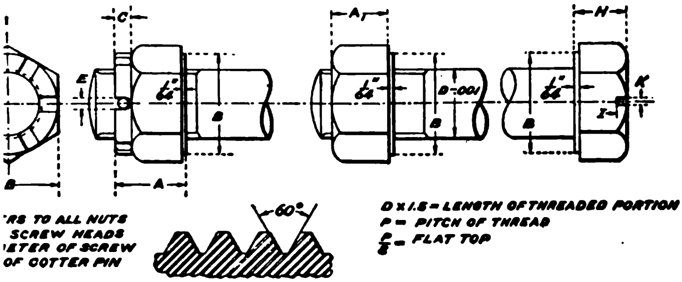
Sea water is 1.6 to 1.9 heavier than fresh water.

1 cubic inch of water makes approximately 1 cubic foot of steam at atmospheric pressure.

27222 cubic feet of steam at atmospheric pressure weighs 1 pound.

[redacted]

S. A. E. Screw Standard



	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
	28	24	24	20	20	18	18	16	16	14	14	12	12	12	12
	9/32	21/64	13/32	29/64	9/16	39/64	23/32	49/64	13/16	29/32	1	1 5/32	1 1/4	1 13/32	1 1/2
	7/32	17/64	21/64	3/8	7/16	31/64	35/64	19/32	21/32	49/64	7/8	63/64	1 3/32	1 13/64	1 5/16
	7/16	1/2	9/16	5/8	3/4	7/8	15/16	1	1 1/16	1 1/4	1 7/16	1 5/8	1 13/16	2	2 3/16
	3/32	3/32	1/8	1/8	3/16	3/16	1/4	1/4	1/4	1/4	1/4	5/16	5/16	3/8	3/8
	5/64	5/64	1/8	1/8	1/8	5/32	5/32	5/32	5/32	5/32	5/32	7/32	7/32	1/4	1/4
	3/16	15/64	9/32	21/64	3/8	27/64	15/32	33/64	9/16	21/32	3/4	27/32	15/16	1 1/32	1 1/8
	3/32	7/64	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	7/32	7/32	1/4	1/4
	1/16	1/16	3/32	3/32	3/32	3/32	3/32	3/32	3/32	3/32	3/32	5/32	5/32	3/16	3/16
	1/16	1/16	3/32	3/32	3/32	1/8	1/8	1/8	1/8	1/8	1/8	11/64	11/64	13/64	13/64

Calculations of Pulley Diameters and Revolutions

Driving Pulley being called the Driver, and the Driven Pulley the Driven.

$$\text{Diameter of Driver} = \frac{\text{Diameter of Driven} \times \text{Revolutions of Driven}}{\text{Revolutions of Driver}}$$

$$\text{Diameter of Driven} = \frac{\text{Diameter of Driver} \times \text{Revolutions of Driver}}{\text{Revolutions of Driven}}$$

$$\text{Revolutions of Driver} = \frac{\text{Diameter of Driven} \times \text{Revolutions of Driven}}{\text{Diameter of Driver}}$$

$$\text{Revolutions of Driven} = \frac{\text{Diameter of Driver} \times \text{Revolutions of Driver}}{\text{Diameter of Driven}}$$

STANDARD HEXAGON BOLTS AND NUTS.

Diameter of Tap.	Threads per Inch.	Mill.	Across Corners.	Thickness U. S. Standard.	Depth of Thread.	Exact Size of Hole.	Tap Drill Used.	Width of Flat.	Area at Root of Thread.	Safe Strain in lbs. — Iron at 50,000 lbs. per sq. in. — Factor of Safety 5
¼	20	½	37/64	¼	.0295	.1910	13/64	.0056	.0286	286
5/16	18	19/32	11/16	5/16	.0361	.2403	17/64	.0069	.0452	452
⅜	16	11/16	51/64	⅜	.0406	.2938	19/64	.0078	.0677	677
7/16	14	25/32	29/32	7/16	.0464	.3447	23/64	.0089	.0932	932
½	13	⅞	1 1/64	½	.0500	.4001	13/32	.0096	.1257	1257
9/16	12	31/32	1⅛	9/16	.0542	.4542	15/32	.0104	.1620	1620
⅝	11	1 1/16	1 15/64	⅝	.0590	.5069	33/64	.0114	.2018	2018
¾	10	1¼	1 29/64	¾	.0650	.6201	⅝	.0125	.3020	3020
⅞	9	1 7/16	1 43/64	⅞	.0722	.7307	47/64	.0139	.4194	4194
1	8	1⅝	1⅞	1	.0812	.8376	27/32	.0156	.5509	5509
1⅛	7	1 13/16	2 3/32	1⅛	.0928	.9394	61/64	.0179	.6930	6930
1¼	7	2	2 5/16	1¼	.0928	1.0644	1 5/64	.0179	.8890	8890
1⅜	6	2 3/16	2 17/32	1⅜	.1083	1.1585	1 11/64	.0208	1.0540	10540
1½	6	2⅜	2¾	1½	.1083	1.2835	1 19/64	.0208	1.2930	12935
1¾	5	2¾	3 3/16	1¾	.1300	1.4902	1 33/64	.0250	1.7440	17441
2	4½	3⅛	3 39/64	2	.1444	1.7113	1 23/32	.0278	2.3900	23000
2¼	4½	3½	4 3/64	2¼	.1444	1.9613	1 31/32	.0278	3.0210	30214
2½	4	3⅞	4 31/64	2½	.1625	2.1752	2 3/16	.0313	3.7140	37149
2¾	4	4¼	4 59/64	2¾	.1625	2.4252	2 7/16	.0313	4.6180	46181
3	3½	4⅝	5 11/32	3	.1857	2.6288	2 41/64	.0357	5.4270	54275

GENERAL FORMULÆ, ETC.

1. Mill or distance across flats equals 1½ times the diameter of Tap, plus ⅛ inch.
2. Across corners or long diameter equals 1.155 times the mill. Table gives nearest 1/64 larger.
3. Exact depth of thread equals .65 times the pitch. Width of flat on thread equals ⅛ the pitch.
4. Exact size of hole U. S. Standard equals diameter Tap minus $\frac{1.299}{\text{No. threads per in.}}$ Tap Drill nearest 1/64 larger.
5. Bolt Heads same dimensions as Nuts.

[redacted]

MACHINE SCREW TABLE.

auge :.	Diameter in Decimals.	Approximate Diameter.	No. Threads per Inch.	Size of Tap Drill.
	.0842	5/64	56	49
	.0973	3/32	48	45
	.1105	7/64	36	42
	.1236	1/8	36	38
	.1368	9/64	32	35
	.1500	5/32	32	30
	.1631	5/32	32	29
	.1763	11/64	30	27
	.1894	3/16	24	25
	.2026	13/64	24	21
	.2158	7/32	24	17
	.2289	[illegible]	22	15
	.2421	[illegible]	20	13
	.2552	1/4	20	8
	.2684	17/64	18	6
	.2816	9/32	18	2
	.2947	19/64	18	1
	.3079	5/16	18	C
	.3210	21/64	16	D
	.3474	11/32	16	J
	.3737	3/8	16	N
	.4000	13/32	16	P
	.4263	27/64	14	R
	.4528	29/64	14	U

WEIGHTS OF METALS

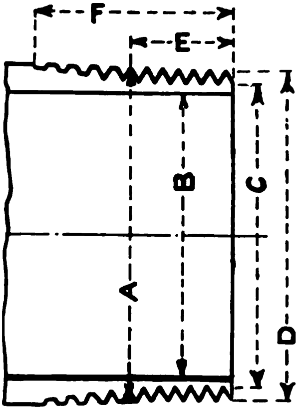
	Lbs. per Cu. Ft.	Lbs. per Cu. In.
n, cast	160	0926
:t	506.3	.293
›et	528	3056
ıetal	440.6	.255
luminum	471.2	2727
hosphor	575.8	3332
ire	555.1	3212
	450.	2604
iron, bars	486.8	.2817
semer	490.7	.284
t	709.5	4106
	548.7	.3175
	458.3	.2652
	436.5	.2526

WROUGHT IRON WELDED STEAM, GAS AND WATER PIPE. TABLE OF STANDARD DIMENSIONS.—NATIONAL TUBE WORKS CO.

Diameter.			Thickness.	Circumference.		Transverse Areas.			Length of Pipe per Sq. Foot of		Length of Pipe containing One Cubic Foot	Nominal Weight per Foot.	No. of Threads per Inch of Screw.
Nominal Internal.	Actual External.	Actual Internal.		External.	Internal.	External.	Internal.	Metal.	External Surface	Internal Surface.			
Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Sq. Ins.	Sq. Ins.	Sq. Ins.	Ft	Ft	Ft	Lbs.	
1/8	.405	.27	.068	1.272	.848	.129	.0573	.0717	9 44	14.15	2513.	.241	27
1/4	.54	.364	.088	1.696	1.144	.229	.1041	.1249	7.075	10 49	1383.3	.42	18
3/8	.675	.494	.091	2.121	1.552	.358	.1917	.1683	5 657	7.73	751.2	.559	18
1/2	.84	.623	.109	2.639	1.957	.554	.3048	.2492	4 547	6.13	472.4	.837	14
3/4	1.05	.824	.113	3.299	2 589	.866	.5333	.3327	3.637	4.635	270.	1.115	14
1	1.315	1.048	.134	4.131	3.292	1 358	.8626	.4954	2 904	3.645	166 9	1.668	11½
1¼	1.66	1.38	.14	5 215	4.335	2.164	1.496	.668	2.301	2.768	96.25	2.244	11½
1½	1.9	1.611	.145	5.969	5.061	2.835	2 038	.797	2.01	2.371	70.66	3.678	11½
2	2.375	2.067	.154	7.461	6.494	4.43	3.356	1.074	1.608	1.848	42.91	4.609	11½
2½	2.875	2.468	.204	9.032	7.753	6.492	4.784	1.708	1 328	1.547	30.1	5.739	8
3	3.5	3.067	.217	10.996	9.636	9.621	7 388	2.243	1.091	1.245	19.5	7.536	8
3½	4.	3.548	.226	12.566	11.146	12 566	9.887	2 679	.955	1.077	14.57	9 001	8
4	4.5	4.026	.237	14.137	12.648	15.904	12 73	3.174	.849	.949	11.31	10.665	8
4½	5.	4.508	.246	15.708	14.162	19.635	15.961	3.674	.764	.848	9.02	12.34	8
5	5.563	5.045	.259	17.477	15.849	24.306	19 99	4.316	.687	.757	7.2	14.502	8
6	6.625	6.065	.28	20.813	19 054	34.472	28 888	5.584	.577	.63	4.98	18.762	8
7	7.625	7.023	.301	23.955	22.063	45 664	38.738	6.926	.501	.544	3.72	23.271	8
8	8.625	7.982	.322	27.096	25.076	58.426	50.04	8.396	.443	.478	2.88	28.177	8
9	9.625	8.937	.344	30.238	28.076	72.76	62.73	10 03	.397	.427	2.29	33.701	8
10	10.75	10.019	.366	33.772	31.477	90.763	78.839	11.924	.355	.382	1.82	40.065	8
11	12.	11.25	.375	37.699	35.343	113.098	99.402	13 696	.318	.339	1.456	45.95	8
12	12.75	12.	.375	40.055	37.7	127.677	113.098	14.579	.299	.319	1.27	48 985	8

Wrought Iron Welded Pipe and Pipe Threads

Briggs' Standard



A—Outside diameter of perfect thread or actual outside diameter of pipe.

B—Inside diameter of pipe.

C—Root diameter of thread at end.

D—Outside diameter of thread at end.

E—Length of perfect thread = P(4.8+0.8A)

F—Total length of thread or length of taper at top.

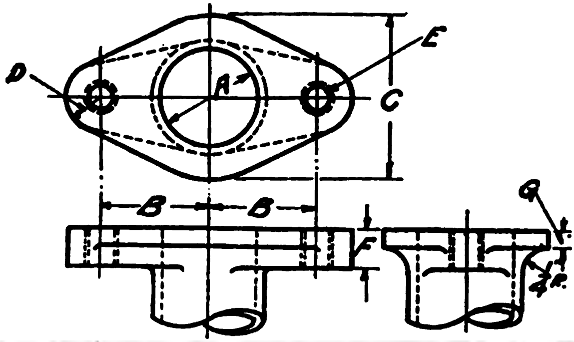
N—Number of threads per inch.

P—Pitch of thread = $\frac{1}{N}$

Taper of thread, ¾″ per foot or 1 in 32 to axis of pipe.

Diam. of Tube in Ins.			Nominal Weight per ft. lbs.	Internal Area sq. ins.	Pipe Thread Dimensions					Size of Tap Drill
Nominal Inside	Actual Inside B	Actual Outside A			C	D	E	F	N	
⅛	0.270	0.405	.24	.057	.334	.393	.19	.41	27	11/32
¼	0.364	0.540	.42	.104	.433	.522	.29	.62	18	29/64
⅜	0.494	0.675	.55	.192	.567	.656	.30	.63	18	19/32
½	0.623	0.840	.83	.305	.702	.816	.39	.82	14	47/64
¾	0.824	1.050	1.11	.533	.911	1.025	.40	.83	14	15/16
1	1.048	1.315	1.66	.863	1.144	1.283	.51	1.03	11½	1 3/16
1¼	1.380	1.660	2.24	1.496	1.488	1.627	.54	1.06	11½	1 17/32
1½	1.610	1.900	2.67	2.038	1.727	1.866	.55	1.07	11½	1 49/64
2	2.067	2.375	3.60	3.355	2.200	2.339	.58	1.10	11½	2¼
2½	2.468	2.875	5.73	4.783	2.618	2.818	.89	1.64	8	2 21/32
3	3.067	3.500	7.53	7.388	3.243	3.443	.95	1.70	8	3 19/64
3½	3.548	4.000	9.00	9.887	3.738	3.938	1.00	1.75	8	3 25/32
4	4.026	4.500	10.66	12.73	4.233	4.443	1.05	1.80	8	4 9/32
4½	4.508	5.000	12.34	15.93	4.733	4.933	1.10	1.85	8	4 25/32
5	5.045	5.563	14.50	19.99	5.289	5.489	1.16	1.91	8	5 11/32
6	6.065	6.625	18.76	28.88	6.347	6.547	1.26	2.01	8	6 25/64
7	7.023	7.625	23.27	38.73	7.340	7.540	1.36	2.11	8	....
8	7.982	8.625	28.17	50.03	8.332	8.532	1.46	2.21	8	....
9	9.000	9.625	33.70	63.63	9.324	9.524	1.56	2.31	8	....
10	10.019	10.750	40.06	78.83	10.44	10.64	1.67	2.42	8	....

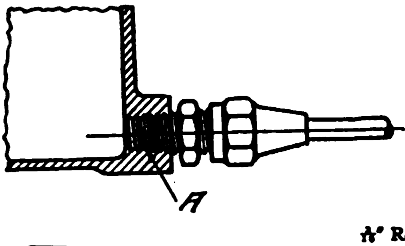
CARBURETER FITTINGS—Flanges



Carbureter Size	A	B	C	D	E*	F	G
3/4	15/16"	1 1/16"	1 5/8"	11/32"	5/16"x18 thr.	3/8"	1/8"
7/8	1 1/16"	1 1/8"	1 3/4"	11/32"	5/16"x18 thr.	3/8"	1/8"
✓1	1 3/16"	1 3/16"	1 7/8"	11/32"	5/16"x18 thr.	13/32"	3/32"
1 1/4	1 7/16"	1 11/32"	2 3/16"	13/32"	3/8"x16 thr.	13/32"	3/32"
1 1/2	1 11/16"	1 15/32"	2 1/2"	13/32"	3/8"x16 thr.	15/32"	3/32"
1 3/4	1 15/16"	1 21/32"	2 13/16"	15/32"	7/16"x14 thr.	9/16"	3/32"
2	2 3/16"	1 25/32"	3 1/8"	15/32"	7/16"x14 thr.	9/16"	3/32"

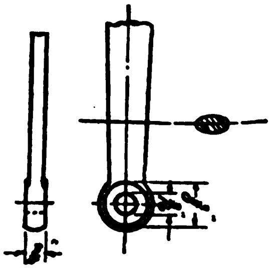
*U. S. Standard thread.
All dimensions in inches.

GASOLINE PIPE SIZES

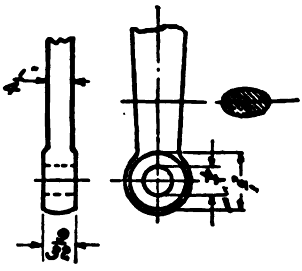


Carbureter Size	A, Briggs Standard. Pipe Thread
3/4"	[illegible]
7/8"	[illegible]
1"	[illegible]
1 1/4"	[illegible]
1 1/2"	[illegible]
1 3/4"	[illegible]
2"	[illegible]

THROTTLE LEVERS



5/16" Rod end for carbureters up to 1 inch.



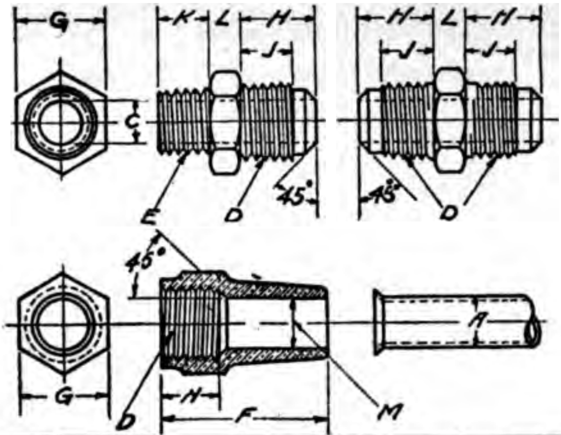
1/4" Rod end for carbureters of 1 1/4 to 2 inches inclusive

Recommended by the Standards Committee and accepted by the Society of Automobile Engineers, June, 1912.

[redacted]

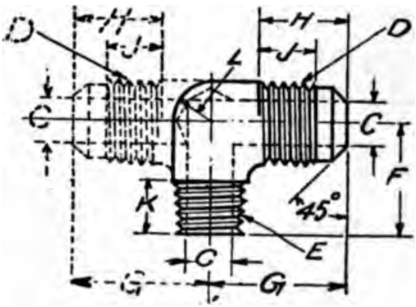
CARBURETER FITTINGS

Flared Tube Unions



A	Pipe diameter	1/4	5/16	3/8	7/16	1/2
C	Bore, male part	3/16	7/32	9/32	5/16	11/32
D	S. A. E. thread	7/16x20 thr.	1/2x20 thr.	5/8x18 thr.	11/16x16 thr.	3/4x16 thr.
E	Pipe thread	1/8	1/8	1/4	1/4	3/8
F		1 1/32	1 1/8	1 3/16	1 1/4	1 3/8
G		9/16	5/8	3/4	13/16	7/8
H		7/16	9/16	5/8	11/16	3/4
J	Thread only	11/32	3/8	13/32	7/16	1/2
K	Thread only	3/8	3/8	7/16	7/16	1/2
L		3/16	7/32	1/4	9/32	5/16
M	Bore, female part	0.255–0.257	0.317–0.319	0.380–0.382	0.442–0.444	0.505–0.507
N		11/32	3/8	7/16	1/2	9/16

FLARED TUBE ELLS AND TEES



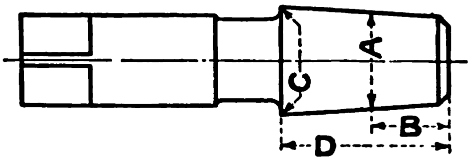
A	Tube diameter	1/4	5/16	3/8	7/16	1/2
C	Drill diameter	3/16	7/32	9/32	5/16	11/32
D	S. A. E. thread	7/16x20	1/2x20	5/8x18	11/16x16	3/4x16
E	Briggs std. pipe thread	1/8	1/8	1/4	3/8	3/8
F	Center to face	3/4	3/4	7/8	15/16	1
G	Center to face	3/4	13/16	1	1 1/8	1 3/16
H		1/2	9/16	5/8	11/16	3/4
J	Thread only	11/32	3/8	13/32	7/16	1/2
K	Thread only	3/8	3/8	7/16	7/16	1/2
L	Radius	1/8	1/4	9/32	5/16	11/32

All dimensions on this sheet in inch measure.

Recommended by the Standards Committee and accepted by the Society of Automobile Engineers, June, 1912.

Pipe Tap Dimensions

Briggs' Standard

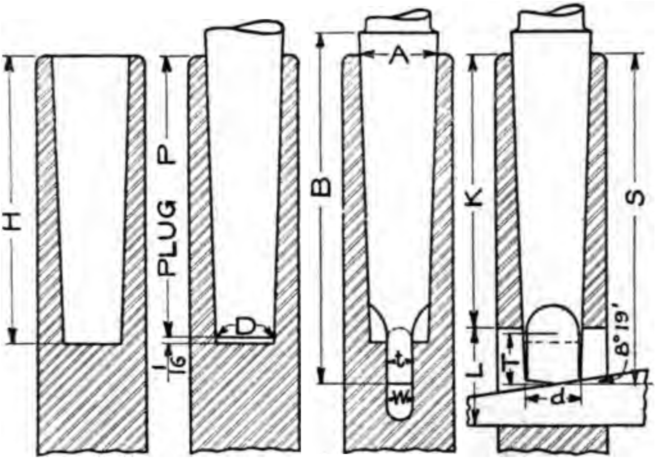


Nom. Pipe Size	Diam. at Size Line A	Dist. End to Size Line B	Diam. at large End C	Length of Thread D	Nom. Pipe Size	Diam. at Size Line A	Dist. End to Size Line B	Diam. at large End C	Length of Thread D
1/8	0.405	13/32	0.443	1	3	3.500	1 7/16	3.605	3 1/4
1/4	0.540	9/16	0.575	1 1/8	3 1/2	4.000	1 5/8	4.125	3 3/8
3/8	0.675	9/16	0.718	1 1/4	4	4.500	1 11/16	4.629	3 1/2
1/2	0.840	3/4	0.887	1 1/2	4 1/2	5.000	1 7/8	5.125	3 5/8
3/4	1.050	3/4	1.104	1 5/8	5	5.563	2	5.687	4
1	1.315	15/16	1.366	1 3/4	6	6.625	2 1/4	6.766	4 1/4
1 1/4	1.660	31/32	1.717	1 7/8	7	7.625	2 5/16	7.773	4 1/2
1 1/2	1.900	1	1.963	2	8	8.625	2 3/8	8.773	4 5/8
2	2.375	1	2.453	2 1/4	9	9.625	2 1/2	9.781	5
2 1/2	2.875	1 1/2	2.961	2 3/8	10	10.750	2 1/2	10.906	5

Whitworth's Gas and Water Piping

Diam. of Piping Internal	Diam. of Piping External	Diam. at Bottom of Thread	No. of Thr'ds per in.	Size of Tap Drill	Diam. of Piping Internal	Diam. of Piping External	Diam. at Bottom of Thread	No. of Thr'ds per in.	Size of Tap Drill
1/8	.3825	.3367	28	11/32	1 7/8	2.245	2.1285	11	2 5/32
1/4	.518	.4506	19	15/32	2	2.347	2.2305	11	2 15/64
3/8	.6563	.5889	19	19/32	2 1/8	2.467	2.3505	11	2 23/64
1/2	.8257	.7342	14	47/64	2 1/4	2.5875	2.4710	11	2 31/64
5/8	.9022	.8107	14	53/64	2 3/8	2.794	2.6775	11	2 11/16
3/4	1.041	.9495	14	31/32	2 1/2	3.0013	2.8848	11	2 29/32
7/8	1.189	1.0975	14	1 1/8	2 5/8	3.124	3.0075	11	3 1/32
1	1.309	1.1925	11	1 7/32	2 3/4	3.247	3.1305	11	3 5/32
1 1/8	1.492	1.3755	11	1 25/64	2 7/8	3.367	3.2505	11	3 9/32
1 1/4	1.650	1.5335	11	1 9/16	3	3.485	3.3685	11	3 13/32
1 3/8	1.745	1.6285	11	1 21/32	3 1/4	3.6985	3.5820	11	3 5/8
1 1/2	1.8825	1.7660	11	1 25/32	3 1/2	3.912	3.7955	11	3 13/16
1 5/8	2.021	1.9045	11	1 15/16	3 3/4	4.1255	4.0090	11	4 1/32
1 3/4	2.047	1.9305	11	1 31/32	4	4.339	4.2225	11	4 15/64

Morse Tapers



umber of Taper..............		No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
iameter of Plug at Small End....................	D	.369	.572	.778	1.02	1.475	2.116
tandard Plug Depth....	P	$2\frac{1}{8}$	$2\frac{9}{16}$	$3\frac{3}{16}$	$4\frac{1}{16}$	$5\frac{3}{16}$	$7\frac{1}{4}$
epth of Hole......	H	$2\frac{3}{16}$	$2\frac{5}{8}$	$3\frac{1}{4}$	$4\frac{1}{8}$	$5\frac{1}{4}$	$7\frac{3}{8}$
nd of Socket to Keyway	K	$2\frac{1}{16}$	$2\frac{1}{2}$	$3\frac{1}{16}$	$3\frac{7}{8}$	$4\frac{15}{16}$	7
ength of Keyway.......	L	$\frac{3}{4}$	$\frac{7}{8}$	$1\frac{1}{16}$	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$
idth of Keyway........	W	.213	.265	.330	.490	.650	.780
ength of Tongue.......	T	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{3}{4}$	1
iameter of Shank at Small End.............	d	.353	.553	.753	.991	1.440	2.064
hickness of Tongue	t	$\frac{13}{64}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{15}{32}$	$\frac{5}{8}$	$\frac{3}{4}$
hank Depth	S	$2\frac{7}{16}$	$2\frac{15}{16}$	$3\frac{11}{16}$	$4\frac{5}{8}$	$5\frac{7}{8}$	$8\frac{1}{4}$
hole Length of Shank..	B	$2\frac{11}{16}$	$3\frac{3}{16}$	$3\frac{15}{16}$	$5\frac{1}{8}$	$6\frac{1}{8}$	$8\frac{3}{4}$
iameter at End of Socket	A	.475	.700	.938	1.231	1.748	2.494
aper per Foot..........		.600	.602	.602	.623	.630	.626
mallest Drill Using Each Taper..................		$\frac{1}{8}$	$\frac{19}{32}$	$\frac{59}{64}$	$1\frac{17}{64}$	$2\frac{1}{64}$	$3\frac{1}{16}$
argest Drill Using Each Taper..................		$\frac{37}{64}$	$\frac{29}{32}$	$1\frac{1}{4}$	2	3	6

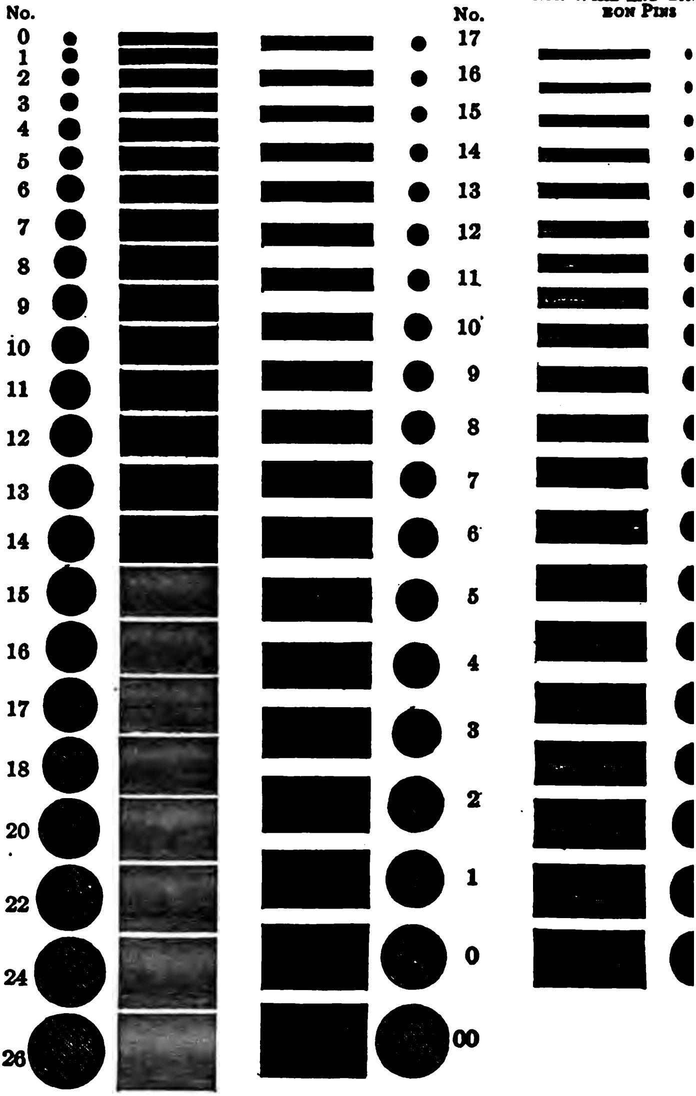
Taper of key=$1\frac{1}{4}$" in 12".

COMPARISON OF GAUGES

SCREW GAUGE
USED FOR WOOD & MACHINE SCREWS

ENGLISH STANDARD GAUGE
USED FOR IRON RIVETS

WASHBURN & M GAUGE
USED FOR WIRE N
IRON WIRE AND ESC
EON PINS



FERENT STANDARDS FOR WIRE GAUGES

IN USE IN THE UNITED STATES

Dimensions of Sizes in Decimal Parts of an Inch

of uge	American or Brown & Sharpe	Birmingham or English Standard	Washburn & Moen Mfg Co. Worcester, Mass.	Imperial Wire Gauge	Stubs' Steel Wire	Number of Wire Gauge
)0	....	....	.....	.464	....	000000
0	....	....	.....	.432	....	00000
)	.46	.454	.3938	.400	....	0000
	.40964	.425	.3625	.372	....	000
	.3648	.38	.3310	.348	....	00
	.32486	.34	.3065	324	....	0
	.2893	.3	.2830	.300	.227	1
	.25763	.284	.2625	.276	.219	2
	.22942	.259	.2437	.252	.212	3
	.20431	.238	.2253	.232	.207	4
	.18194	.22	.2070	.212	.204	5
	.16202	.203	.1920	.192	.201	6
	.14428	.18	.1770	.176	.199	7
	.12849	.165	.1620	.160	.197	8
	.11443	.148	.1483	.144	.194	9
	.10189	.134	.1350	.128	.191	10
	.090742	.12	.1205	.116	.188	11
	.080808	.109	.1055	.104	.185	12
	.071961	.095	.0915	.092	.182	13
	.064084	.083	.0800	.080	.180	14
	.057068	.072	.0720	.072	.178	15
	.05082	.065	.0625	.064	.175	16
	.045257	.058	.0540	.056	.172	17
	.040303	.049	.0475	.048	.168	18
	.03589	.042	.0410	.040	.164	19
	.031961	.035	.0348	.036	.161	20
	.028462	.032	.03175	.032	.157	21
	.025347	.028	.0286	.028	.155	22
	.022571	.025	.0258	.024	.153	23
	.0201	.022	.0230	.022	.151	24
	.0179	.02	.0204	.020	.148	25
	.01594	.018	.0181	.018	.146	26
	.014195	.016	.0173	.0164	.143	27
	.012641	.014	.0162	.0149	.139	28
	.011257	.013	.0150	.0136	.134	29
	.010025	.012	.0140	.0124	.127	30
	.008928	.01	.0132	.0116	.120	31
	.00795	.009	.0128	.0108	.115	32
	.00708	.008	.0118	.0100	.112	33
	.006304	.007	.0104	.0092	.110	34
	.005614	.005	.0095	.0084	.108	35
	.005	.004	.0090	.0076	.106	36
	.004453	....	.....	.0068	.103	37
	.003965	....	.....	.0060	.101	38
	.003531	....	.....	.0052	.099	39
	.003144	....	.....	.0048	.097	40

DIFFERENT STANDARDS FOR WIRE GAUG

IN USE IN THE UNITED STATES

Dimensions of Sizes in Decimal Parts of an Inch

Number of Wire Gauge	H., S. & Co. "F. & G." Steel Music Wire Gauge	Screw Gauge	London Gauge	U. S. Standard for Plate	[illegible]
000000	......	......	......	.46875	000
00000	......	......	......	.4375	000
0000	......	......	.454	.40625	000
000	......	......	.425	.375	000
00	.0087	......	.380	.34375	00
0	.0093	.0578	.340	.3125	0
1	.0098	.0710	.300	.28125	1
2	.0106	.0842	.284	.265625	2
3	.0114	.0973	.259	.25	3
4	.0122	.1105	.238	.234375	4
5	.0138	.1236	.220	.21875	5
6	.0157	.1368	.203	.203125	6
7	.0177	.1500	.180	.1875	7
8	.0197	.1631	.165	.171875	8
9	.0216	.1763	.148	.15625	9
10	.0236	.1894	.134	.140625	10
11	.0260	.2026	.120	.125	11
12	.0283	.2158	.109	.109375	12
13	.0303	.2289	.095	.09375	13
14	.0323	.2421	.083	.078125	14
15	.0342	.2552	.072	.0703125	15
16	.0362	.2684	.065	.0625	16
17	.0382	.2816	.058	.05625	17
18	.04	.2947	.049	.05	18
19	.042	......	.040	.04375	19
20	.044	.3210	.035	.0375	20
21	.046	......	.0315	.034375	21
22	.048	.3474	.0295	.03125	22
23	.051	......	.027	.028125	23
24	.055	.3737	.025	.025	24
25	.059	......	.023	.021875	25
26	.063	.4000	.0205	.01875	26
27	.067	......	.01875	.0171875	27
28	.071	.4263	.0165	.015625	28
29	.074	......	.155	.0140625	29
30	.078	.4520	.01375	.0125	30
31	.082	......	.01225	.0109375	31
32	.086	......	.01125	.01015625	32
33	......	......	.01025	.009375	33
34	......	......	.0095	.00859375	34
35	......	......	.009	.0078125	35
36	......	......	.0075	.00703125	36
37	......	......	.0065	.006640625	37
38	......	......	.00575	.00625	38
39	......	......	.005	....	39
40	......	......	.0045	....	40

[redacted]

Twist Drill Gauge Sizes

No. Drill	Decimal Sizes	No. Drill	Decimal Sizes
1	.2280	31	.1200
2	.2210	32	.1160
3	.2130	33	.1130
4	.2090	34	.1110
5	.2055	35	.1100
6	.2040	36	.1065
7	.2010	37	.1040
8	.1990	38	.1015
9	.1960	39	.0995
10	.1935	40	.0980
11	.1910	41	.0960
12	.1890	42	.0935
13	.1850	43	.0890
14	.1820	44	.0860
15	.1800	45	.0820
16	.1770	46	.0810
17	.1730	47	.0785
18	.1695	48	.0760
19	.1660	49	.0730
20	.1610	50	.0700
21	.1590	51	.0670
22	.1570	52	.0635
23	.1540	53	.0595
24	.1520	54	.0550
25	.1495	55	.0520
26	.1470	56	.0465
27	.1440	57	.0430
28	.1405	58	.0420
29	.1360	59	.0410
30	.1285	60	.0400

Letter Sizes

A .234	H .266	O .316	U .368
B .238	I .272	P .323	V .377
C .242	J .277	Q .332	W .386
D .246	K .281	R .339	X .397
E .250	L .290	S .348	Y .404
F .257	M .295	T .358	Z .413
G .261	N .302		

Sizes of Drills to be used with V Thread, Hand and Nut Taps

Size of Tap	Size of Drill	Size of Tap	Size of Drill
1/4 X 20	3/16	15/16 X 9	25/32
5/16 X 18	15/64	1 X 8	53/64
3/8 X 16	19/64	1 1/8 X 7	15/16
7/16 X 14	11/32	1 1/4 X 7	1 1/16
1/2 X 12	25/64	1 3/8 X 6	1 9/64
9/16 X 12	29/64	1 1/2 X 6	1 17/64
5/8 X 11	1/2	1 5/8 X 5	1 11/32
11/16 X 11	9/16	1 3/4 X 5	1 15/32
3/4 X 10	39/64	1 7/8 X 4 1/2	1 37/64
13/16 X 10	43/64	2 X 4 1/2	1 11/16
7/8 X 9	23/32		

Formula for finding proper size of Drills for all pitches of V Threads:

Example: 3/4 X 10 Tap.

$1.400 \div 10 = .140 - .750 = .610$, size of Root Diameter, or size of Drill to be used.

Note.—For U. S. Standard Threads use same formula except use 1. of pitch instead of 1.4.

[redacted]

TABLE OF EMERY WHEEL SPEEDS.

Diam. Wheel	Rev. per Minute for Surface Speed of 4,000 Feet.	Rev. per Minute for Surface Speed of 5,000 Feet.	Rev. per Minute for Surface Speed of 6,000 Feet.
1 inch.	15,279	19,099	22,918
2 "	7,639	9,549	11,459
3 "	5,093	6,366	7,639
4 "	3,820	4,775	5,730
5 "	3,056	3,820	4,584
6 "	2,546	3,183	3,820
7 "	2,183	2,728	3,274
8 "	1,910	2,387	2,865
10 "	1,528	1,910	2,292
12 "	1,273	1,592	1,910
14 "	1,091	1,364	1,637
16 "	955	1,194	1,432
18 "	849	1,061	1,273
20 "	764	955	1,146
22 "	694	868	1,042
24 "	637	796	955
26 "	588	734	879
28 "	546	683	819
30 "	509	637	764
32 "	477	596	716
34 "	449	561	674
36 "	424	531	637
38 "	402	503	603
40 "	382	478	573
42 "	364	455	546
44 "	347	434	521
46 "	332	415	498
48 "	318	397	477
50 "	306	383	459
52 "	294	369	441
54 "	283	354	425
56 "	273	341	410
58 "	264	330	396
60 "	255	319	382

THE SPEED OF DRILLS.

Cleveland Twist Drill Co.

Diam. of Drill.	Speed for Soft Steel.	Speed for Iron.	Speed for Brass.	Diam. of Drill.	Speed for Soft Steel.	Speed for Iron.	Speed for Brass.
1/16	1,824	2,128	3,648	1 1/16	108	125	215
1/8	912	1,064	1,824	1 1/8	101	118	203
3/16	608	710	1,216	1 3/16	96	112	192
1/4	456	532	912	1 1/4	91	106	182
5/16	365	425	730	1 5/16	87	101	174
3/8	304	355	608	1 3/8	83	97	166
7/16	260	304	520	1 7/16	80	93	159
1/2	228	266	456	1 1/2	76	89	152
9/16	203	236	405	1 9/16	73	85	145
5/8	182	213	365	1 5/8	70	82	140
11/16	166	194	332	1 11/16	68	79	135
3/4	152	177	304	1 3/4	65	76	130
13/16	140	164	280	1 13/16	63	73	125
7/8	130	152	260	1 7/8	60	71	122
15/16	122	142	243	1 15/16	59	69	118
1	114	133	228	2	57	67	114

Table of Allowances for Grinding

Length / Diam.	3″	6″	9″	12″	15″	18″	24″	30″	36″
½	.010	.010	.010	.010	.015	.015	.015	.020	.020
¾	.010	.010	.010	.010	.015	.015	.015	.020	.020
1	.010	.010	.010	.015	.015	.015	.015	.020	.020
1¼	.010	.010	.015	.015	.015	.015	.015	.020	.020
1½	.010	.015	.015	.015	.015	.015	.020	.020	.020
2	.015	.015	.015	.015	.015	.020	.020	.020	.020
2¼	.015	.015	.015	.015	.020	.020	.020	.020	.020
2½	.015	.015	.015	.020	.020	.020	.020	.020	.025
3	.015	.015	.020	.020	.020	.020	.020	.025	.025
3½	.015	.020	.020	.020	.020	.020	.025	.025	.025
4	.020	.020	.020	.020	.020	.025	.025	.025	.025
4½	.020	.020	.020	.020	.025	.025	.025	.025	.025
5	.020	.020	.020	.025	.025	.025	.025	.025	.030
6	.020	.020	.025	.025	.025	.025	.025	.030	.030
7	.020	.025	.025	.025	.025	.025	.030	.030	.030
8	.025	.025	.025	.025	.025	.030	.030	.030	.030
9	.025	.025	.025	.025	.030	.030	.030	.030	.030
10	.025	.025	.025	.030	.030	.030	.030	.030	.030
11	.025	.025	.030	.030	.030	.030	.030	.030	.030
12	.030	.030	.030	.030	.030	.030	.030	.030	.030

[W]EIGHT IN POUNDS OF A LINEAL FOOT OF ROUND, SQUARE AND OCTAGON STEEL

[Siz]e [in Inch]es	Round	Octagon	Square	Size in Inches	Round	Octagon	Square
[illegible]	.010	.011	.013	2½	16.79	17.71	21.37
[illegible]	.042	.044	.053	2⅝	18.51	19.52	23.56
[illegible]	.094	.099	.120	2¾	20.31	21.42	25.86
[illegible]	.168	.177	.214	2⅞	22.20	23.41	28.27
[illegible]	.262	.277	.334	3	24.17	25.50	30.78
[illegible]	.378	.398	.491	3⅛	26.23	27.66	33.40
[illegible]	.514	.542	.655	3¼	28.37	29.92	36.12
[illegible]	.671	.708	.855	3⅜	30.59	32.27	38.95
[illegible]	.850	.896	1.082	3½	32.90	34.70	41.89
[illegible]	1.049	1.107	1.336	3⅝	35.29	37.23	44.94
[illegible]	1.270	1.339	1.616	3¾	37.77	39.84	48.09
[illegible]	1.511	1.594	1.924	3⅞	40.33	42.54	51.35
[illegible]	1.773	1.870	2.258	4	42.97	45.33	54.72
[illegible]	2.056	2.169	2.618	4¼	48.51	51.17	61.77
[illegible]	2.361	2.490	3.006	4½	54.39	57.37	69.25
	2.686	2.833	3.420	4¾	60.60	63.92	77.16
	3.399	3.585	4.328	5	67.15	70.83	85.50
	4.197	4.427	5.344	5¼	74.03	78.08	94.26
	5.078	5.356	6.466	5½	81.25	85.70	103.45
	6.044	6.374	7.695	5¾	88.80	93.67	113.07
	7.093	7.481	9.031	6	96.69	101.99	123.12
	8.226	8.674	10.474	7	131.61	138.82	167.58
	9.443	9.960	12.023	8	171.90	181.32	218.88
	10.744	11.332	13.680	9	217.57	229.48	277.02
	12.129	12.793	15.443	10	268.60	283.31	342.00
	13.598	14.343	17.314	11	325.01	342.80	413.82
	15.151	15.981	19.291	12	386.79	407.97	492.48

PROPORTIONATE WEIGHT OF CASTINGS TO WEIGHT OF WOOD PATTERNS

Pattern Weighing One Pound, Made of ([les]s Weight of Core Prints)	Cast Iron	Brass	Copper	Bronze	Bell Metal	Zinc
[Pine] or Fir	16	15.8	16.7	16.3	17.1	13.5
[illegible]	9.	10.1	10.4	10 3	10.9	8.6
[...]h	9.7	10.9	11.4	11.3	11.9	9.1
[...]en	13.4	15.1	16.7	15.5	16.3	12.9
[illegible]	10.2	11.5	11.9	11.8	12 4	9.8
[...]l	10.6	11.9	12.3	12.2	12.9	10.2
[illegible]	12.8	14.3	14.9	14.7	15.5	12.2
[Mah]ogany	11.7	13.2	13 7	13 5	14.2	11.2
[illegible]	0.85	0.95	0.99	0 98	1.0	0.81

ALLOWANCES FOR FITS IN AUTOMOBILE CONSTRUCTION

Fits in automobile construction can be divided into,

Force Fits.

To be used in parts where disassembling will hardly be required, and whic assembled by means of hydraulic or screw presses, or when hot.

Driving Fits.

To be used in parts where close adherence is required, but which must be a bled and disassembled with no other help than an ordinary hammer; such a wheels, gear wheels, ball-bearing inner races, etc.

Push Fits.

To be used in parts without relative motion in actual work but which have sufficient freedom to be assembled by hand; such as bolts, slip joints, bearing outer races, etc.

Running Fits.

To be used in parts possessed of relative motion in normal running; thes be subdivided into,

Easy Fits; where great freedom of running is required with possibility of lubrication, such as valve guides, control connections, clutch shafts, etc.

Close Fits; to be used in all high-speed work and especially the engine and mission.

Fine Fits; to be used in parts where great accuracy is required or where, the motion is slight the stresses are of an alternating or vibratory natur as connecting rod small ends, steering connections etc.; efficient lubri must be provided if the motion is frequently recurring.

Fit Allowances

In the allowances given in the following the expansion of metals when of di nature or exposed to heat in a different degree, such as is the case in some parts of construction, has not been taken into account.

Allowance Over Nominal Diameter for Force Fits

Nominal diameter	½"	1"	2"	
Maximum "	0.50100	1 00200	2 00400	3
Minimum "	0.50050	1.00150	2.00300	3

Allowance Over Nominal Diameter for Driving Fits

Nominal diameter	½"	1"	2"	
Maximum "	0.50050	1.00100	1 00125	1
Minimum "	0.50025	1.00075	1.00100	1

Allowance Below Nominal Diameter for Push Fits

Nominal diameter	½"	1"	2"	
Maximum "	0.49975	0.99950	1.99900	2
Minimum "	0.49925	0.99900	1.99850	2

Allowance Below Nominal Diameter for Running Fits

EASY FITS

Nominal diameter	½"	1"	2"
Maximum "	0.49900	0.99875	1.99825
Minimum "	0.49800	0.99725	1.99650

CLOSE FITS

Nominal diameter	½"	1"	2"
Maximum "	0.59925	0.99900	1 99875
Minimum "	0.59875	0.99800	1.99750

FINE FITS

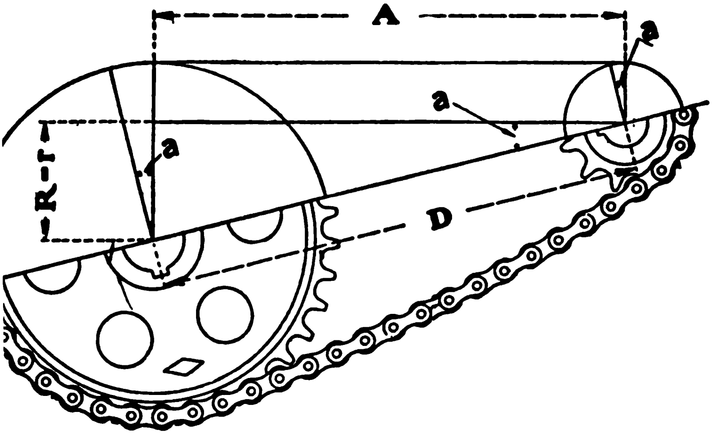
Nominal diameter	½"	1"	2"
Maximum "	0.59950	0.99925	1.99925
Minimum "	0.59925	0.99875	1.99850

For intermediate dimensions comparison between the size immediately below a immediately above will give the safe allowances in each case.

[redacted]

FORMULA FOR CALCULATING LENGTH OF CHAIN

(DIAMOND CHAIN AND MFG. CO.)



(All Dimensions in Inches)

Distance between centers.
Distance between limits of contact.
Pitch radius of large sprocket.
'itch radius of small sprocket.
No. of teeth on large sprocket.
Jo. of teeth on small sprocket.
Pitch of chain and sprockets.
+ 2 α = Angle of contact—large sprocket.
+ 2 α = Angle of contact—small sprocket.

$$\alpha = Sin^{-1}\frac{R-r}{D}$$

$$A = D \; Cos \; \alpha$$

length of chain.

$$L = \frac{180 + 2\alpha}{360} NP + \frac{180 - 2\alpha}{360} nP + 2D \, Cos \, \alpha$$

Engine Lathe Gearing for Cutting Threads

Refer to the screw cutting table and see what number of turns to an inch is cut with equal gears. This number is the number of turns to an inch that we assume the lead screw has, no matter what its real number of turns to an inch is.

Simple Gearing.

Write the number of turns to an inch of the lead screw above a line, and the number of turns to an inch of the screw to be threaded below the line, thus expressing the ratio in the form of a fraction, the lead screw being the numerator and screw to be threaded the denominator. Now find an equal fraction in terms that represent numbers of teeth in available gears. The numerator of this new fraction will be the spindle or stud gear and the denominator the lead screw gear. The new fraction is usually found by multiplying the numerator and denominatar of the first fraction by the same number.

EXAMPLE—Required to cut a screw having 11½ threads per inch. We find on the index that 48 to 48 cuts 4 threads per inch then $\frac{4}{11\frac{1}{2}} \times \frac{6}{6} = \frac{24}{69}$

Put the 24 tooth gear on the stud and the 69 tooth gear on the lead screw to cut 11½ threads per inch.

Any multiplier may be used to obtain gears that are available.

Compound Gearing.

Write the number of turns to an inch of the lead screw as the numerator of a fraction and the turns of the screw to be threaded as the denominator.

Factor this fraction into an equal compound fraction.

Change the terms of this compound fraction either by multiplying or dividing into another equal compound fraction whose terms represent numbers of teeth in available gears.

Then the two terms in the numerator represent the number of teeth in the gears to be used as drivers and those in the denominator the gears to be used as driven gears.

EXAMPLE—Required to cut a screw having 3¼ inches lead or $\frac{4}{13}$ turns to an inch. Lead screw is 1½ inches lead or ⅔ turns to an inch.

$$\frac{2}{3} \div \frac{4}{13} = \frac{2 \times 13}{3 \times 4} = \frac{2 \times 13}{1 \times 12}$$

Multiply numerator and demoninator by 5. $\frac{2 \times (13 \times 5)}{1 \times (12 \times 5)} = \frac{2 \times 65}{1 \times 60}$

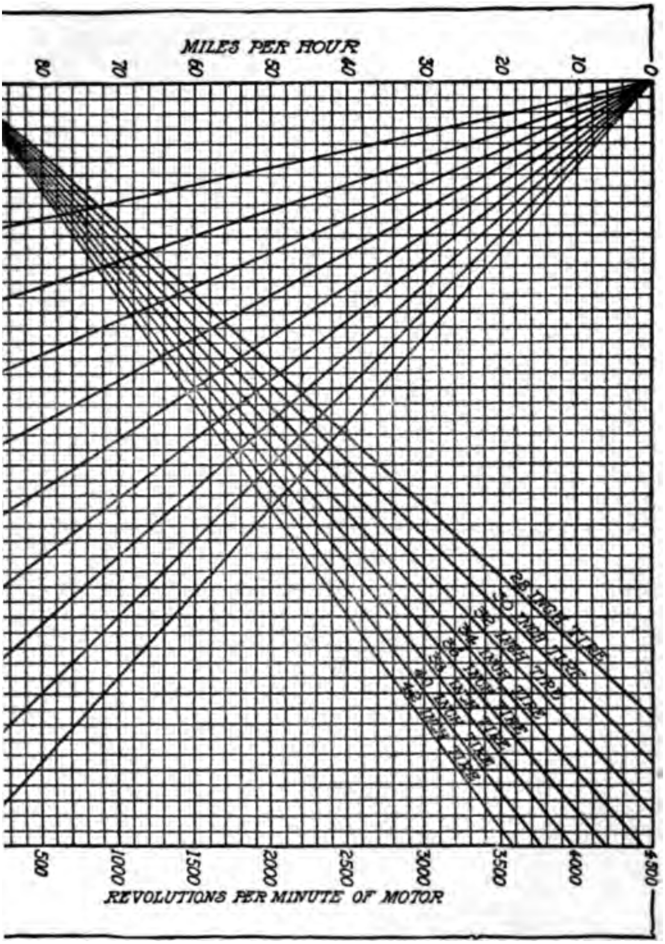
Multiply numerator and denominator by 24. $\frac{(24 \times 2) \times 65}{(24 \times 1) \times 60} = \frac{48 \times 65}{24 \times 60}$

The 48 tooth and 65 tooth gears will be the drivers and the 24 tooth and 60 tooth gears the driven.

Any multiplier may be used to obtain gears that are available.

HOW TO USE CHART OF GEAR RATIOS, TIRE SIZES A CRANKSHAFT REVOLUTIONS PER MINUTE

Given the miles per hour, gear ratio, and tire sizes and revolutions of a crankshaft per minute: For illustration, sup the car is traveling at 80 miles per hour with 34-inch tires a gear ratio of 1.5 to 1. From the figure 80 move right to the i section of the gear ratio line designed as 1.5. From this point i up to the diagonal of 34 inches. From this point move rigl

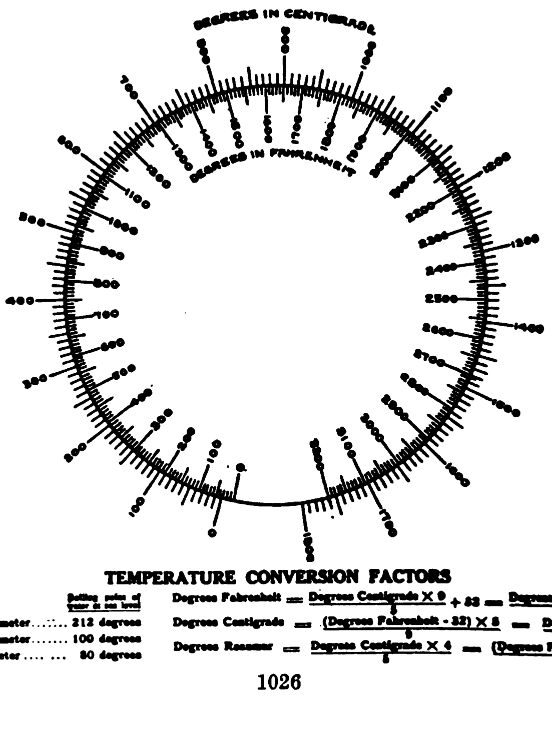


gin where the revolutions of the crankshaft speed per min-
shown; 1,200 in this case. Given the crankshaft revolutions
ute, the tire diameters and miles per hour, find the gear
Supposing the motor is turning over at 1,000 revolutions
ute, that 42-inch tires are used, and the car is traveling at
per hour. Go left from the 1,000 on the right margin until
rsection of the 42-inch tire-size line. From this point go

up to the intersection of the 50-mile-per-hour horizontal lin intersection of this line also cuts the gear ratio of 2.7 line, w the gear ratio employed.

Given crankshaft revolutions per minute, size of tires ar ratio, in order to find miles per hour, proceed as follows: from crankshaft speed—say 1,000 revolutions per minute— size—say 28-inch. From this point go up or down to inter of gear ratio line—say 1.5. Then go left to 55 miles per ho we have given crankshaft speed in revolutions per minute per hour and gear ratio, the tire sizes may be obtained by left from crankshaft speed to the intersection of the gear rat and thence up or down to the miles per hour, which point wil the intersection of the required tire diameter.

COMPARATIVE SCALE — Fahrenheit & Centigrade Thermom



TEMPERATURE CONVERSION FACTORS

	Boiling point of water at sea level
Fahrenheit thermometer	212 degrees
Centigrade thermometer	100 degrees
Reaumur thermometer	80 degrees

Degrees Fahrenheit = $\frac{\text{Degrees Centigrade} \times 9}{5} + 32 = \frac{\text{Degrees Reaum}}{4}$

Degrees Centigrade = $\frac{(\text{Degrees Fahrenheit} - 32) \times 5}{9} = \text{Degrees R}$

Degrees Reaumur = $\frac{\text{Degrees Centigrade} \times 4}{5} = \frac{(\text{Degrees Fahrenhe}}{9}$

[...]E PER MILE EXPRESSED IN MILES PER HOUR

[...]e for [...] mile [...]. Sec.		Miles Per hour	Time for one mile Min. Sec.			Miles Per hour	Time for one mile Min. Sec.			Miles Per hour
36	=	100.00	1	12	=	50.00	1	47	=	33.64
37	=	97.30	1	13	=	49.31	1	48	=	33.33
38	=	94.74	1	14	=	48.65	1	49	=	33.03
39	=	92.31	1	15	=	48.00	1	50	=	32.72
40	=	90.00	1	16	=	47.37	1	51	=	32.43
41	=	87.80	1	17	=	46.75	1	52	=	32.14
42	=	85.71	1	18	=	46.15	1	53	=	31.86
43	=	83.72	1	19	=	45.57	1	54	=	31.58
44	=	81.82	1	20	=	45.00	1	55	=	31.30
45	=	80.00	1	21	=	44.44	1	56	=	31.03
46	=	78.26	1	22	=	43.90	1	57	=	30.77
47	=	76.60	1	23	=	43.37	1	58	=	30.50
48	=	75.00	1	24	=	42.36	1	59	=	30.25
49	=	73.47	1	25	=	42.35	2	0	=	30.00
50	=	72.00	1	26	=	41.86	2	3	=	29.26
51	=	70.59	1	27	=	41.38	2	6	=	28.57
52	=	69.23	1	28	=	40.91	2	9	=	27.90
53	=	67.92	1	28	=	40.91	2	9	=	27.90
54	=	66.67	1	29	=	40.45	2	12	=	27.27
55	=	65.45	1	30	=	40.00	2	15	=	26.66
56	=	64.29	1	31	=	39.56	2	18	=	26.08
57	=	63.16	1	32	=	39.13	2	21	=	25.53
58	=	62.07	1	33	=	38.71	2	24	=	25.00
59	=	61.02	1	34	=	38.30	2	27	=	24.49
0	=	60.00	1	35	=	37.89	2	30	=	24.00
1	=	59.02	1	36	=	37.50	2	33	=	23.53
2	=	58.06	1	37	=	37.11	2	36	=	23.07
3	=	57.14	1	38	=	36.73	2	39	=	22.64
4	=	56.25	1	39	=	36.36	2	42	=	22.22
5	=	55.38	1	40	=	36.00	2	45	=	21.81
6	=	54.55	1	41	=	35.64	2	48	=	21.42
7	=	53.73	1	42	=	35.29	2	51	=	21.05
8	=	52.94	1	43	=	34.95	2	54	=	20.69
9	=	52.17	1	44	=	34.61	3	0	=	20.00
10	=	51.42	1	45	=	34.28	..	..		....
11	=	50.70	1	46	=	33.96	..	...		....

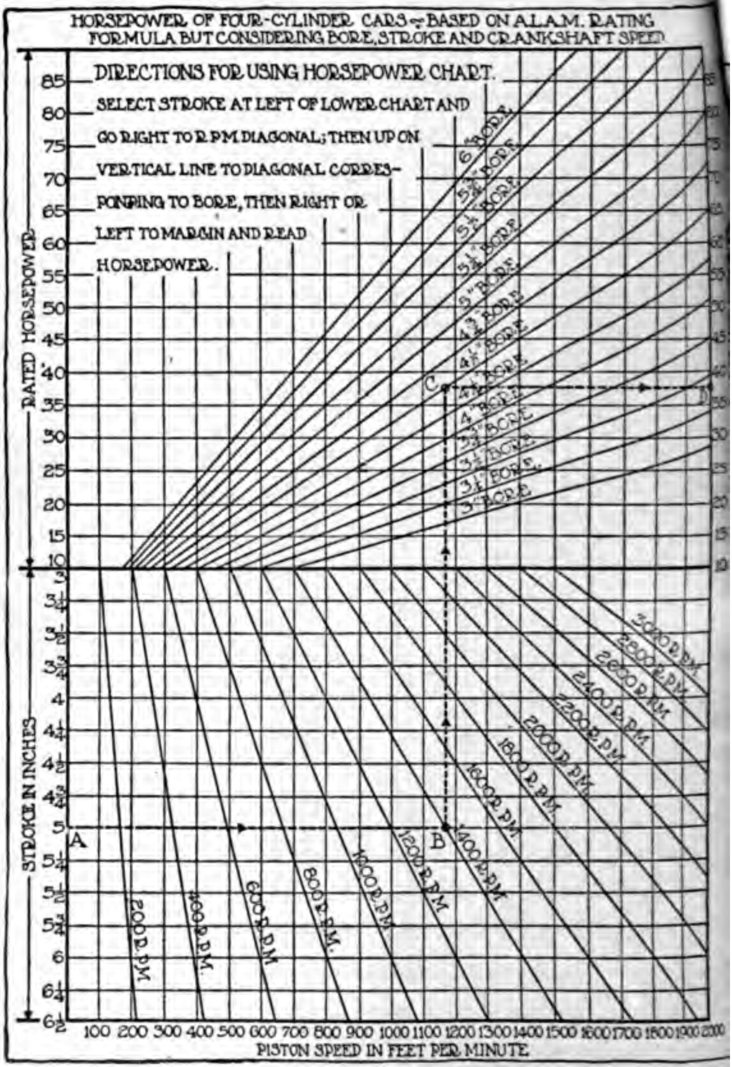
ENGLISH AND METRIC SPEED EQUIVALENTS

To obtain velocity in feet per second multiply the speed in miles per [...]r by 1.466+

Velocity ft. per sec. = Miles per hour x 1.466+

One mile per hour = 1.466 ft. per second = 88 ft. per minute = 0.447 [...]ers per second = 26.8 metres per minute.

1 Km. per hour = 0.914 metres per second = 54.9 ft. per minute = 0.624 [...] per hour.


HORSEPOWER OF FOUR-CYLINDER CARS — BASED ON A.L.A.M. RATING FORMULA BUT CONSIDERING BORE, STROKE AND CRANKSHAFT SPEED
DIRECTIONS FOR USING HORSEPOWER CHART.
SELECT STROKE AT LEFT OF LOWER CHART AND GO RIGHT TO R.P.M. DIAGONAL; THEN UP ON VERTICAL LINE TO DIAGONAL CORRESPONDING TO BORE, THEN RIGHT OR LEFT TO MARGIN AND READ HORSEPOWER.
RATED HORSEPOWER
STROKE IN INCHES
PISTON SPEED IN FEET PER MINUTE
6" BORE
5¾" BORE
5½" BORE
5¼" BORE
5" BORE
4¾" BORE
4½" BORE
4¼" BORE
4" BORE
3¾" BORE
3½" BORE
3¼" BORE
3" BORE
200 R.P.M.
400 R.P.M.
600 R.P.M.
800 R.P.M.
1000 R.P.M.
1200 R.P.M.
1400 R.P.M.
1600 R.P.M.
1800 R.P.M.
2000 R.P.M.
2200 R.P.M.
2400 R.P.M.
2600 R.P.M.
2800 R.P.M.
3000 R.P.M.
A
B
C
D

ROXIMATE HORSEPOWER OF FOUR-CYCLE AUTOMOBILE ENGINES*

Table of Constants for Variable Speeds and Strokes

oke Ins.	Revolutions per Minute of Motor														
	500	550	600	650	700	750	800	850	900	950	1,000	1,050	1,100	1,150	1,200
....	0.89	.098	.107	.116	.124	.134	.142	.153	.161	.169	.178	.187	.196	.205	214
....	.100	.110	.120	.130	.140	.151	.160	.171	.181	.190	.200	.210	.220	.231	.241
....	.112	.125	.133	.145	.156	.167	.176	.189	.201	.212	.223	.233	.245	.257	.268
....	.123	.135	.146	.159	.172	.184	.196	.208	.221	.233	.245	.256	.270	.282	.295
....	.134	.147	.160	.174	.187	.201	.214	.227	.241	.254	.267	.279	.294	.308	.322
....	.145	.158	.173	.188	.203	.219	.232	.246	.261	.275	.289	.303	.319	.333	.349
....	.156	.173	.186	.203	.218	.234	.250	.265	.281	.296	.312	.326	.343	.359	.375
....	.167	.184	.200	.218	.234	.252	.266	.284	.301	.317	.334	.349	.368	.385	.401
....	.178	.196	.214	.232	.249	.268	.285	.303	.321	.339	.356	.373	.392	.411	.429
....	.189	.208	.227	.246	.264	.285	.303	.322	.341	.360	.378	.396	.416	.436	.456
....	.200	.220	.240	.261	.280	.305	.321	.341	.361	381	.400	.419	.441	.461	.485
....	.212	.233	.253	.275	.295	.319	.339	.360	.381	.402	.423	.443	.466	.486	.509
....	.223	.245	.266	.290	.312	.335	.357	.379	.401	.423	.445	.466	.491	.512	.536
....	.234	.257	.279	.304	.327	.351	.375	.398	.421	.444	.467	.490	.515	.538	.563
....	.245	.270	.293	.318	.343	.368	.393	.417	.441	.465	.489	.513	.540	.564	.590
....	.258	.282	.307	.332	.369	.385	.410	.436	461	.486	.512	.536	.564	.589	.616
....	.268	.294	.320	.348	.375	.402	.428	.455	.481	.508	535	.559	.589	.615	.643

Bore Ins.	Square of Bore
.00	4.00
.25	5.06
.50	6.25
.75	7.55
.00	9.00
.25	10.56
.50	12.25
.75	14.05
.00	16.00
.25	18.05
.50	20.20
.75	22.55
.00	25.00
.25	27.50
.50	30.20
.75	33.05
.00	36.00

Rule:—Multiply number to right of bore by number in upper table at intersection of proper R.P.M. and stroke columns.

Example:—Find approximate horsepower developed by motor having 4.25″ bore and 5″ stroke at 800 revolutions per minute.

Under 4.25 bore we find 18.05.

At intersection of 5″ stroke line and 800 R.P.M. column in upper table we find .357.

The product of these numbers gives the horsepower, thus:

Approximate norsepower = 18.05 × .357 = 6 45 H.P.

These figures have been computed for the average M.E.P. as found in the ordinary motor car engine, but of course will vary with increase or decrease in compression and with different mechanical efficiencies.

*For multi-cylinder engines, multiply by number of cylinders. Above formula gives H.P. for only one cylinder.

Two-cycle Engines

D = Diameter of cylinder in *inches*. L = Stroke of piston in *inches*. R = Re
lutions per minute of crank shaft. n = Number of cylinders.

Authority for Formula	Factors Used	Constant or Divisor
Roberts. Gas.	$D^2 \times L \times R \times n$	14000
Roberts. Gasoline.	$D^2 \times L \times R \times n$	13500
American Power Boat Association.*	$D^2 \times n$	$\frac{1.65}{7854} = 2.1008$
Same for less than 6 inches stroke.	$D^2 \times L \times n$	$\frac{12 \times .85}{\times 7854} =$ *12.987

*The above are for automobile racing boat engines; for others the rating is ta
as two-thirds of the above formulas. For engines having a displacer cylinde
cylinders the above rating is increased in the ratio that the displacer piston's displ
ment bears to that of the working cylinders.

INDICATED HORSEPOWER

On account of the great difficulty of securing good indicator cards at the high-pi
and rotative speeds of automobile motors this is very little employed. The manog
which is employed for obtaining cards or diagrams from high-speed motors, as a ge
thing does not have an equal pressure scale and therefore does not readily lend i
to the accurate determination of I. H. P.

The indicated H. P. may of course be determined approximately by assumi
certain mechanical efficiency for the motor under consideration. This varies
as high as 90 per cent. in some cases to lower than 70 per cent. in others; the av
would probably be not far from 80 per cent.

The formula for I. H. P., the bore and stroke being known as well as the R. P
and the mean effective pressure, is,

$$\frac{D^2 \times L \times R.P.M. \times n \times M.E.P.}{\dfrac{33{,}000 \times 12 \times 2}{.7854}} = I.H.P. \text{ (for 4-cycle).}$$

This constant equals 550,000 and the formula becomes $\dfrac{D^2 \times L \times n \times M.E.P.}{550{,}000}$.

The constant for 2-cycle is 275,000.

A formula which is given by Grover for the mean effective pressure, the compre
being known, is as follows:

$$M.E.P. = 2C - 0.01\,C^2$$

C = Compression pressure above atmosphere in pounds per square inch.

This formula does not hold good for compression pressures over 100 pounds
square inch above atmosphere. Comparatively recent data seems to prove the relia
of this formula, also the fact, which Grover points out, that under favorable
ditions, the values given by this formula may be slightly exceeded. Tests with h
pressures than 100 pounds show that the M. E. P. tends to remain at 100 pounds
square inch.

The compression pressure may be obtained by some form of gauge, the ign
for that cylinder being cut off, or in case the volume of the explosion chamber is kn
it may be obtained from the formula.

$PV^{1.3}$ = Constant. P being the absolute pressure.

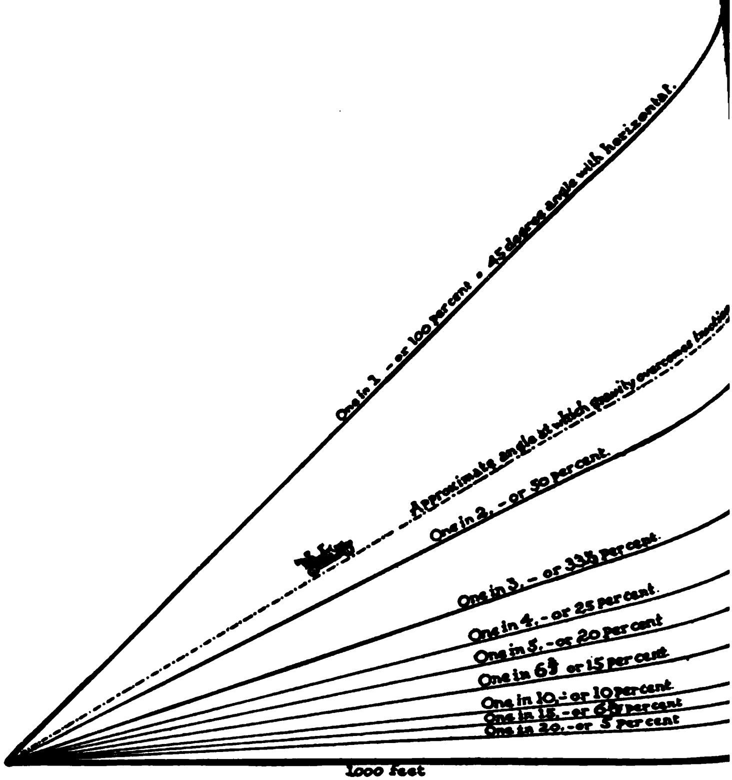
V being taken in the one case as the volume of the combustion chamber and i
other as the above plus the piston displacement. P being in one case atmosp
pressure and in the other the absolute compression pressure. Of course for C in Gro
formula the assumed atmospheric pressure should be subtracted from the resul
tained by this formula.

COMPRESSION PRESSURE WITH DIFFERENT CYLINDER CLEARANCES

Cylinder Clearance, in Per Cent. of Piston Displacement	Mechanical Compression Ratio	Compression Pressure, Pounds per Square Inch Absolute		
		Low	Medium	High
20	6.	100	130	154
21	5.76	95	125	145
22	5.55	91	120	138
23	5.35	87	115	132
24	5.17	83	110	126
25	5.	80	105	121
26	4.85	77	101	116
27	4.70	74	97	111
28	4.57	71½	94	107
29	4.45	69	90	103
30	4.33	67	87	99
31	4.23	65	84	96
32	4.125	63	81½	93
33	4.03	61½	79	91
34	3.94	60	77	88
35	3.86	58	75	85
36	3.78	56½	73	83
37	3.70	55	71	81
38	3.63	54	69	79
39	3.56	53	67½	77
40	3.5	52	66	75

Computed by Cecil P. Poole.

MEASUREMENT OF GRADES



ILLUSTRATING METHOD OF CALCULATING GRADE PERCENTAGES

If it be assumed that the base of the triangle represents a line 1,000 f long and that the first sloping line represents a road having a rise that bri it 50 feet above the starting point, this is figured as 50 feet in a thousa or 5 per cent. In other words, one foot of rise for every 20 feet, but latter instance does not mean distance actually traveled by a car in ascend such a slope, but distance measured horizontally with reference to t slope. The grade is measured by the tangent of the angle of inclinat and not by its sine, so that a grade which represents 100 per cent. co sponds to an angle of inclination of but 45 degrees, and not 90 degrees perpendicular, as is commonly supposed. At the upper end of the n sloping line the elevation would amount to 66⅔ feet, which is equivalent t rise of one foot for every 6⅔ feet traveled horizontally. So one in three co sponds to a 33 1-3 per cent. grade, one in two to a 50 per cent. grade, and on until a 100 per cent. grade is reached, which, as noted, is the equivalen a 45 degree angle.

TABLE OF GRADIENTS

GRADE		Equal to Angle of	Rise or Fall in One Mile, Feet
Per Cent	Units		
20	1 in 5	11° 19′	1056
17	1 " 6	9° 26′	880
14	1 " 7	8° 09′	754
12.5	1 " 8	7° 08′	635
11	1 " 9	6° 17′	586
10	1 " 10	5° 43′	528
9	1 " 11	5° 11′	480
8	1 " 12	4° 46′	440
7.75	1 " 13	4° 24′	406
7	1 " 14	4° 05′	337
6.5	1 " 15	3° 49′	352
6.25	1 " 16	3° 35′	330
6	1 " 17	3° 22′	310
5.5	1 " 18	3° 11′	293
5	1 " 19	3° 00′	277
5	1 " 20	2° 52′	204
4	1 " 25	2° 18′	218
3.3	1 " 30	1° 55′	155
2.8	1 " 35	1° 38′	151
2.5	1 " 40	1° 26′	132

INDEX

A

B

C

F

G

H

I

J

K

L

N

O

P

Q

R

S

Z

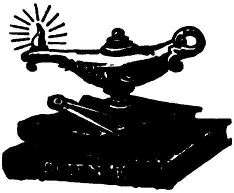
CATALOGUE

Of the LATEST *and* BEST

PRACTICAL *and* MECHANICAL

BOOKS

Including Automobile and Aviation Books



Any of these books will be sent prepaid to any part of the world, on receipt of price. Remit by Draft, Postal Order, Express Order or Registered Letter

Published and For Sale By

The Norman W. Henley Publishing Co.,

2 West 45th Street, New York, U.S.A.

AUTOMOBILES AND MOTORCYCLES

rn Gasoline Automobile—Its Design, Construction, and Opera-, 1918 Edition. By VICTOR W. PAGÉ, M.S.A.E.

is the most complete, practical and up-to-date treatise on gasoline automobiles and their onent parts ever published. In the new *revised* and *enlarged* 1918 *edition*, all phases of nobile construction, operation and maintenance are fully and completely described, and guage anyone can understand. Every part of all types of automobiles, from light cycle-to heavy motor trucks and tractors, are described in a thorough manner, not only itomobile, but every item of it; equipment, accessories, tools needed, supplies and spare necessary for its upkeep, are fully discussed.

learly and concisely written by an expert familiar with every branch of the automobile industry e originator of the practical system of self-education on technical subjects. It is a liberal edu- in the automobile art, useful to all who motor for either business or pleasure.

ne reading the incomparable treatise is in touch with all improvements that have been in motor-car construction. All latest developments, such as high speed aluminum motors nultiple valve and sleeve-valve engines, are considered in detail. The latest ignition, retor and lubrication practice is outlined. New forms of change speed gears, and final transmission systems, and all latest chassis improvements are shown and described. book is used in all leading automobile schools and is conceded to be the STANDARD TISE. The chapter on Starting and Lighting Systems has been greatly enlarged, and automobile engineering features that have long puzzled laymen are explained so clearly the underlying principles can be understood by anyone. This book was first published ars ago and so much new matter has been added that it is nearly twice its original size. nly treatise covering various forms of war automobiles and recent developments in motor-design as well as pleasure cars. *This book is not too technical for the layman nor too elementary e more expert. It is an incomparable work of reference for home or school.* 1,000 6x9 pages, 1,000 illustrations, 12 folding plates. Cloth bound. Price **$3.00**

WHAT IS SAID OF THIS BOOK:

the best book on the Automobile seen up to date."—J. H. Pile, Associate Editor *Auto-e Trade Journal.*

ry Automobile Owner has use for a book of this character."—*The Tradesman.*

book is superior to any treatise heretofore published on the subject."—*The Inventive Age.*

know of no other volume that is so complete in all its departments, and in which the wide of automobile construction with its mechanical intricacies is so plainly handled, both in xt and in the matter of illustrations."—*The Motorist.*

book is very thorough, a careful examination failing to disclose any point in connection the automobile, its care and repair, to have been overlooked."—*Iron Age.*

Pagé has done a great work, and benefit to the Automobile Field."—W. C. Hasford, Y. M. C. A. Automobile School, Boston, Mass.

just the kind of a book a motorist needs if he wants to understand his car."—*American herman.*

l T Ford Car, Its Construction, Operation and Repair. By VICTOR PAGÉ, M.S.A.E.

is a complete instruction book. All parts of the Ford Model T Car are described and ated; the construction is fully described and operating principles made clear to everyone. Ford owner needs this practical book. You don't have to guess about the construction ere the trouble is, as it shows how to take all parts apart and how to locate and fix all . The writer, Mr. Pagé, has operated a Ford car for many years and writes from actual ledge. Among the contents are: 1. The Ford Car: Its Parts and Their Functions. e Engine and Auxiliary Groups. How the Engine Works—The Fuel Supply System—Carburetor—Making the Ignition Spark—Cooling and Lubrication. 3. Details of Chassis. ge Speed Gear—Power Transmission—Differential Gear Action—Steering Gear—Front —Frame and Springs—Brakes. 4. How to Drive and Care for the Ford. The Control m Explained—Starting the Motor—Driving the Car—Locating Roadside Troubles—Repairs—Oiling the Chassis—Winter Care of Car. 5. Systematic Location of Troubles Remedies. Faults in Engine—Faults in Carburetor—Ignition Troubles—Cooling and cation System Defects—Adjustment of Transmission Gear—General Chassis Repairs. *strations, 300 pages,* 2 large folding plates. Price **$1.00**

timing practice, eight and
trations, 11 folding plat

"'Automobile Repairing
the only book I ever saw t
"I wish to thank you for
not think it could be excel
delphia, Pa.

Questions and Answers
Driving and Repair.

A practical self-instructor f
lessons in the form of quest
ments of the non-technical
to all branches of automobil
simple language. If you can'
answers to these and over 2,
portant parts of an automobi
of kerosene carburetors. Wh
"dual" ignition system? Na
is an electric motor starter an
ing? Name all important typ
ing axle? What is a two-speed
of lost power in automobiles.
How can you adjust a carbure
in the carburetor? What tool
various makes of cars? What
systems of wire wheel constru
Cloth. 650 pages, 350 illustra

lern Starting, Lighting and Ignition Systems. By VICTOR W. PAGÉ, M.E.

This practical volume has been written with special reference to the requirements of the non-technical reader desiring easily understood, explanatory matter, relating to all types of automobile ignition, starting and lighting systems. It can be undeistood by anyone, even without electrical knowledge, because elementary electrical principles are considered before any attempt is made to discuss features of the various systems. These basic principles are clearly stated and illustrated with simple diagrams. *All the leading systems of starting, lighting and ignition have been described and illustrated with the co-operation of the experts employed by the manufacturers.* Wiring diagrams are shown in both technical and non-technical forms. All symbols are fully explained. It is a comprehensive review of modern starting and ignition system practice, and includes a complete exposition of storage battery construction, care and repair. All types of starting motors, generators, magnetos, and all ignition or lighting system-units are fully explained. *Every person in the automobile business needs this volume.* Among some of the subjects treated are: I.—Elementary Electricity; Current Production; Flow; Circuits; Measurements; Definitions; Magnetism; Battery Action; Generator Action. II.—Battery Ignition Systems. III.—Magneto Ignition Systems. IV.—Elementary Exposition of Starting System Principles. V.—Typical Starting and Lighting Systems; Practical Application; Wiring Diagrams; Auto-lite, Bijur, Delco, Dyneto-Ents, Gray and Davis, Remy, U. S. L., Westinghouse, Bosch-Rushmore, Genemotor, North-East, etc. VI.—Locating and Repairing Troubles in Starting and Lighting Systems. VII.—Auxiliary. Electric Systems; Gear-shifting by Electricity; Warning Signals; Electric Brake; Entz-Transmission, Wagner-Saxon Circuits, Wagner-Studebaker Circuits. 5¼x7½. Cloth. 530 pages, 297 illustrations, 3 folding plates. Price **$1.50**

omobile Welding With the Oxy-Acetylene Flame. By M. KEITH DUNHAM.

This is the only complete book on the "why" and "how" of Welding with the Oxy-Acetylene Flame, and from its pages one can gain information so that he can weld anything that comes along.

No one can afford to be without this concise book, as it first explains the apparatus to be used, and then covers in detail the actual welding of all automobile parts. The welding of aluminum, cast iron, steel, copper, brass and malleable iron is clearly explained, as well as the proper way to burn the carbon out of the combustion head of the motor. Among the contents are: Chapter I.—Apparatus Knowledge. Chapter II.—Shop Equipment and Initial Procedure. Chapter III.—Cast Iron. Chapter IV.—Aluminum. Chapter V.—Steel. Chapter VI.—Malleable Iron, Copper, Brass, Bronze. Chapter VII.—Carbon Burning and other Uses of Oxygen and Acetylene. Chapter VIII.—How to Figure Cost of Welding. 167 pages, fully illustrated. Price **$1.00**

rage Batteries Simplified. By VICTOR W. PAGÉ, M.S.A.E.

A comprehensive treatise devoted entirely to secondary batteries and their maintenance, repair and use.

This is the most up-to-date book on this subject. Describes fully the Exide, Edison, Gould, Willard, U. S. L. and other storage battery forms in the types best suited for automobile, stationary and marine work. Nothing of importance has been omitted that the reader should know about the practical operation and care of storage batteries. No details have been slighted. The instructions for charging and care have been made as simple as possible. Brief Synopsis of Chapters: Chapter I.—Storage Battery Development; Types of Storage Batteries; Lead Plate Types; The Edison Cell. Chapter II.—Storage Battery Construction; Plates and Girds; Planté Plates; Fauré Plates; Non-Lead Plates; Commercial Battery Designs. Chapter III.—Charging Methods; Rectifiers; Converters; Rheostats; Rules for Charging. Chapter IV.—Battery Repairs and Maintenance. Chapter V.—Industrial Application of Storage Batteries; Glossary of Storage Battery Terms. 208 Pages. Very Fully Illustrated. Price . . . . **$1.50 net**

w to Run an Automobile. By VICTOR W. PAGÉ, M.S.A.E.

This treatise gives concise instructions for starting and running all makes of gasoline automobiles, how to care for them, and gives distinctive features of control. Describes every step for shifting gears, controlling engines, etc. Among the chapters contained are: I.—Automobile Parts and Their Functions. II.—General Starting and Driving Instructions. III.—Typical 1917 Control Systems. IV.—Care of Automobiles. 178 pages. 72 specially made illustrations. Price **$1.00**

The Automobilist's Pocket Companion and Expense Record. Arrang
VICTOR W. PAGÉ, M.S.A.E.

This book is not only valuable as a convenient cost record but contains much information of to motorists. Includes a condensed digest of auto laws of all States, a lubrication sch hints for care of storage battery and care of tires, location of road troubles, anti-fr solutions, horse-power table, driving hints and many useful tables and recipes of inte all motorists. Not a technical book in any sense of the word, just a collection of pr facts in simple language for the everyday motorist. Price . . . .

Motorcycles, Side Cars and Cyclecars; their Construction, Manage and Repair. By VICTOR W. PAGÉ, M.S.A.E.

The only complete work published for the motorcyclist and cyclecarist. Describes fu leading types of machines, their design, construction, maintenance, operation and This treatise outlines fully the operation of two- and four-cycle power plants and all ig carburetion and lubrication systems in detail. Describes all representative types engine clutches, variable speed gears and power transmission systems. Gives compl structions for operating and repairing all types. Considers fully electric self-startin lighting systems, all types of spring frames and spring forks and shows leading control me For those desiring technical information a complete series of tables and many form assist in designing are included. The work tells how to figure power needed to climb g overcome air resistance and attain high speeds. It shows how to select gear ratios for v weights and powers, how to figure braking efficiency required, gives sizes of belts and to transmit power safely, and shows how to design sprockets, belt pulleys, etc. This also includes complete formulæ for figuring horse-power, shows how dynamometer tes made, defines relative efficiency of air and water-cooled engines, plain and anti-frictio ings and many other data of a practical, helpful, engineering nature. Remember tha get this information in addition to the practical description and instructions which als worth several times the price of the book. 550 pages. 350 specially made illustrati folding plates. Cloth. Price . . . .

AUTOMOBILE AND MOTORCYCLE CHARTS

Chart. Location of Gasoline Engine Troubles Made Easy—A Chart Sh ing Sectional View of Gasoline Engine. Compiled by VICTOR W. P M.S.A.E.

It shows clearly all parts of a typical four-cylinder gasoline engine of the four-cycle It outlines distinctly all parts liable to give trouble and also details the derangemen to interfere with smooth engine operation.
Valuable to students, motorists, mechanics, repairmen, garagemen, automobile sal chauffeurs, motorboat owners, motor-truck and tractor drivers, aviators, motor-cy and all others who have to do with gasoline power plants.
It simplifies location of all engine troubles, and while it will prove invaluable to the n it can be used to advantage by the more expert. It should be on the walls of every and private garage, automobile repair shop, club house or school. It can be carried automobile or pocket with case, and will insure against loss of time when engine t manifests itself.
This sectional view of engine is a complete review of all motor troubles. It is prepare practical motorist for all who motor. More information for the money than ever offered. No details omitted. Size 25x38 inches. Securely mailed on receipt of 25

Chart. Location of Carbureton Troubles Made Easy. Compiled by Vi W. PAGÉ, M.S.A.E.

This chart shows all parts of a typical pressure feed fuel supply system and gives ca trouble, how to locate defects and means of remedying them. Size 24x38
Price 25

rt. Location of Ford Engine Troubles Made Easy. Compiled by Victor W. Pagé, M.S.A.E.

This shows clear sectional views depicting all portions of the Ford power plant and auxiliary groups. It outlines clearly all parts of the engine, fuel supply system, ignition group and cooling system, that are apt to give trouble, detailing all derangements that are liable to make an engine lose power, start hard or work irregularly. This chart is valuable to students, owners, and drivers, as it simplifies location of all engine faults. Of great advantage as an instructor for the novice, it can be used equally well by the more expert as a work of reference and review. It can be carried in the tool-box or pocket with ease and will save its cost in labor eliminated the first time engine trouble manifests itself. Prepared with special reference to the average man's needs and is a practical review of all motor troubles because it is based on the actual experience of an automobile engineer-mechanic with the mechanism the chart describes. It enables the non-technical owner or operator of a Ford car to locate engine derangements by systematic search, guided by easily recognized symptoms instead of by guesswork. It makes the average owner independent of the roadside repair shop when touring. Must be seen to be appreciated. Size 25x38 inches. Printed on heavy bond paper. Price . . . . 25 cents

rt. Lubrication of the Motor Car Chassis. Compiled by Victor W. Pagé, M.S.A.E.

This chart presents the plan view of a typical six-cylinder chassis of standard design and all parts are clearly indicated that demand oil, also the frequency with which they must be lubricated and the kind of oil to use. A practical chart for all interested in motor-car maintenance. Size 24x38 inches. Price . . . . 25 cents

rt. Location of Ignition System Troubles Made Easy. Compiled by Victor W. Pagé, M.S.A.E.

In this diagram all parts of a typical double ignition system using battery and magneto current are shown, and suggestions are given for readily finding ignition troubles and eliminating them when found. Size 24x38 inches. Price . . . . 25 cents

art. Location of Cooling and Lubrication System Faults. Compiled by Victor W. Pagé, M.S.A.E.

This composite diagram shows a typical automobile power plant using pump circulated water-cooling system and the most popular lubrication method. Gives suggestions for curing all overheating and loss of power faults due to faulty action of the oiling or cooling group. Size 24x38 inches. Price . . . . 25 cents

art. Motorcycle Troubles Made Easy. Compiled by Victor W. Pagé, M.S.A.E.

A chart showing sectional view of a single-cylinder gasoline engine. This chart simplifies location of all power-plant troubles. A single-cylinder motor is shown for simplicity. It outlines distinctly all parts liable to give trouble and also details the derangements apt to interfere with smooth engine operation. This chart will prove of value to all who have to do with the operation, repair or sale of motorcycles. No details omitted. Size 30x20 inches. Price . . . . 25 cents

AVIATION

ation Engines, their Design, Construction, Operation and Repair. By Lieut. Victor W. Pagé, Aviation Section, S.C.U.S.R.

A practical work containing valuable instructions for aviation students, mechanicians, squadron engineering officers and all interested in the construction and upkeep of airplane power plants.

The rapidly increasing interest in the study of aviation, and especially of the highly developed internal combustion engines that make mechanical flight possible, has created a demand for a text-book suitable for schools and home study that will clearly and concisely explain the

workings of the various aircraft engines of foreign and domestic manufacture. This treatise, written by a recognized authority on all of the practical aspects combustion engine construction, maintenance and repair fills the need as no other The matter is logically arranged; all descriptive matter is simply expressed an illustrated so that anyone can understand airplane engine operation and repair e out previous mechanical training. This work is invaluable for anyone desiring t aviator or aviation mechanician.
The latest rotary types, such as the Gnome, Monosoupape, and Le Rhone, are full as well as the recently developed Vee and radial types. The subjects of carburetic cooling and lubrication also are covered in a thorough manner. The chapters on maintenance are distinctive and found in no other book on this subject.
Invaluable to the student, mechanic and soldier wishing to enter the aviation serv Not a technical book, but a practical, easily understood work of reference for al in aeronautical science. 576 octavo pages. 253 specially made engravings. Price . |

GLOSSARY OF AVIATION TERMS

Termes D'Aviation, English-French, French-English. Compiled b VICTOR W. PAGÉ, A.S., S.C.U.S.R., and PAUL MONTARIOL of th Flying Corps, on duty on Signal Corps Aviation School, Mineola, L.

A complete, well illustrated volume intended to facilitate conversation betwe speaking and French aviators. A very valuable book for all who are about to lea overseas.
Approved for publication by Major W. G. Kilner, S.C., U.S.C.O. Signal Cor School. Hazlehurst Field, Mineola, L. I.
This book should be in every Aviator's and Mechanic's Kit for ready reference. Fully illustrated with detailed engravings. Price . . . .

Aviation Chart. Location of Airplane Power Plant Troubles Ma By Lieut. VICTOR W. PAGÉ, A.S., S.C.U.S.R.

A large chart outlining all parts of a typical airplane power plant, showing the p trouble is apt to occur and suggesting remedies for the common defects. Int cially for Aviators and Aviation Mechanics on School and Field Duty. Price . .

BRAZING AND SOLDERING

Brazing and Soldering. By JAMES F. HOBART.

The only book that shows you just how to handle any job of brazing or solderin along; it tells you what mixture to use, how to make a furnace if you need one. F able kinks. The fifth edition of this book has just been published, and to it mucl ter and a large number of tested formulæ for all kinds of solders and fluxes have t Illustrated. Price . . . .

CHARTS

Aviation Chart. Location of Airplane Power Plant Troubles Ma By Lieut. VICTOR W. PAGÉ, A.S., S.C.U.S.R.

A large chart outlining all parts of a typical airplane power plant, showing the p trouble is apt to occur and suggesting remedies for the common defects. Intende for Aviators and Aviation Mechanics on School and Field Duty. Price . . . .

Lubrication of the Motor Car Chassis.

This chart presents the plan view of a typical six-cylinder chassis of standard all parts are clearly indicated that demand oil, also the frequency with which th lubricated and the kind of oil to use. A practical chart for all interested in moto tenance. Size 24x38 inches. Price . . . .

line Engine Troubles Made Easy—A Chart Showing Sectional View of Gasoline Engine. Compiled by Lieut. VICTOR W. PAGÉ, A.S., S.C.U.S.R.

It shows clearly all parts of a typical four-cylinder gasoline engine of the four-cycle type. It outlines distinctly all parts liable to give trouble and also details the derangements apt to interfere with smooth engine operation.
Valuable to students, motorists, mechanics, repairmen, garagemen, automobile salesmen, chauffeurs, motor-boat owners, motor-truck and tractor drivers, aviators, motor-cyclists, and all others who have to do with gasoline power plants.
It simplifies location of all engine troubles, and while it will prove invaluable to the novice, it can be used to advantage by the more expert. It should be on the walls of every public and private garage, automobile repair shop, club house or school. It can be carried in the automobile or pocket with ease and will insure against loss of time when engine trouble manifests itself.
This sectional view of engine is a complete review of all motor troubles. It is prepared by a practical motorist for all who motor. No details omitted. Size 25x38 inches. Price **25 cents**

ation of Carburetion Troubles Made Easy.

This chart shows all parts of a typical pressure feed fuel supply system and gives causes of trouble, how to locate defects and means of remedying them. Size 24x38 inches. Price . . . . **25 cents**

ation of Ignition System Troubles Made Easy.

In this chart all parts of a typical double ignition system using battery and magneto current are shown and suggestions are given for readily finding ignition troubles and eliminating them when found. Size 24x38 inches. Price . . . . **25 cents**

ation of Cooling and Lubrication System Faults.

This composite chart shows a typical automobile power plant using pump circulated water-cooling system and the most popular lubrication method. Gives suggestions for curing all overheating and loss of power faults due to faulty action of the oiling or cooling group. Size 24x38 inches. Price . . . . **25 cents**

torcycle Troubles Made Easy—A Chart Showing Sectional View of Single-Cylinder Gasoline Engine. Compiled by VICTOR W. PAGÉ, M.S.A.E.

This chart simplifies location of all power-plant troubles, and will prove invaluable to all who have to do with the operation, repair or sale of motorcycles. No details omitted. Size 25x38 inches. Price . . . . **25 cents**

ation of Ford Engine Troubles Made Easy. Compiled by VICTOR W. PAGÉ, M.S.A.E.

This shows clear sectional views depicting all portions of the Ford power plant and auxiliary groups. It outlines clearly all parts of the engine, fuel supply system, ignition group and cooling system, that are apt to give trouble, detailing all derangements that are liable to make an engine lose power, start hard or work irregularly. This chart is valuable to students, owners, and drivers, as it simplifies location of all engine faults. Of great advantage as an instructor for the novice, it can be used equally well by the more expert as a work of reference and review. It can be carried in the toolbox or pocket with ease and will save its cost in labor eliminated the first time engine trouble manifests itself. Prepared with special reference to the average man's needs and is a practical review of all motor troubles because it is based on the actual experience of an automobile engineer-mechanic with the mechanism the chart describes. It enables the non-technical owner or operator of a Ford car to locate engine derangements by systematic search, guided by easily recognised symptoms instead of by guesswork. It makes the average owner independent of the roadside repair shop when touring. Must be seen to be appreciated. Size 25x38 inches. Printed on heavy bond paper. Price . . . . **25 cents**

Modern Submarine Chart—with Two Hund

A cross-section view, showing clearly and distin latest type. You get more information from thi tion of a Submarine, than in any other way. and to scale. It is absolutely correct in every d gineers. All the machinery and devices fitted in to make the engraving more readily understood a with Officers and Men in the act of performing ditions. This CHART IS REALLY AN EN is educational and worth many times its cost. Ma

Box Car Chart.

A chart showing the anatomy of a box car, hav proper name given in a reference list. Price . .

Gondola Car Chart.

A chart showing the anatomy of a gondola car, its proper reference name given in a reference list.

Passenger-Car Chart.

A chart showing the anatomy of a passenger-c and its proper name given in a reference list

Steel Hopper Bottom Coal Car.

A chart showing the anatomy of a steel Hopper car numbered and its proper name given in a refe

Tractive Power Chart.

A chart whereby you can find the tractive powe making a figure. Shows what cylinders are eq affect the power. What sized engine you need t desire in this line. Price . . . .

Horse-Power Chart.

Shows the horse-power of any stationary engin cylinder diameter of stroke, the steam pressure densing or non-condensing, it's all there. Easy lations. Especially useful to engineers and desig

Boiler Room Chart. By Geo. L. Fowler.

A chart—size 14x28 inches—showing in isometr a modern boiler room. The various parts are sh construction is fully illustrated. Each part is gi corresponding name, are given in a glossary prin tionary of the boiler room—the names of more tha

COKE

dern Coking Practice, Including Analysis of Materials and Products. By J. E. CHRISTOPHER and T. H. BYROM.

This, the standard work on the subject, has just been revised. It is a practical work for those engaged in Coke manufacture and the recovery of By-products. Fully illustrated with folding plates. It has been the aim of the authors, in preparing this book, to produce one which shall be of use and benefit to those who are associated with, or interested in, the modern developments of the industry. Among the Chapters contained in Volume I are: Introduction; Classification of Fuels; Impurities of Coals; Coal Washing; Sampling and Valuation of Coals, etc.; Power of Fuels; History of Coke Manufacture; Developments in the Coke Oven Design; Recent Types of Coke Ovens; Mechanical Appliances at Coke Ovens; Chemical and Physical Examination of Coke. Volume II covers fully the subject of By-Products.
Price, per volume . . . . **$3.00 net**

COMPRESSED AIR

npressed Air in All Its Applications. By GARDNER D. HISCOX.

This is the most complete book on the subject of Air that has ever been issued, and its thirty-five chapters include about every phase of the subject one can think of. It may be called an encyclopedia of compressed air. It is written by an expert, who, in its 665 pages, has dealt with the subject in a comprehensive manner, no phase of it being omitted. Includes the physical properties of air from a vacuum to its highest pressure, its thermodynamics, compression, transmission and uses as a motive power, in the Operation of Stationary and Portable Machinery, in Mining, Air Tools, Air Lifts, Pumping of Water, Acids, and Oils; the Air Blast for Cleaning and Painting the Sand Blast and its Work, and the Numerous Appliances in which Compressed Air is a Most Convenient and Economical Transmitter of Power for Mechanical Work, Railway Propulsion, Refrigeration, and the Various Uses to which Compressed Air has been applied. Includes forty-four tables of the physical properties of air, its compression, expansion, and volumes required for various kinds of work, and a list of patents on compressed air from 1875 to date. Over 500 illustrations, 5th Edition, revised and enlarged.

Cloth bound. Price **$5.00**
Half Morocco. Price **$6.50**

CONCRETE

ncrete Workers' Reference Books. A Series of Popular Handbooks for Concrete Users. Prepared by A. A. HOUGHTON.

The author, in preparing this Series, has not only treated on the usual types of construction, but explains and illustrates molds and systems that are not patented, but which are equal in value and often superior to those restricted by patents. These molds are very easily and cheaply constructed and embody simplicity, rapidity of operation, and the most successful results in the molded concrete. Each of these books is fully illustrated, and the subjects are exhaustively treated in plain English.

ncrete Wall Forms. By A. A. HOUGHTON.

A new automatic wall clamp is illustrated with working drawings. Other types of wall forms, clamps, separators, etc., are also illustrated and explained. (No. 1 of Series) Price **50 cents**

ncrete Floors and Sidewalks. By A. A. HOUGHTON.

The molds for molding squares, hexagonal and many other styles of mosaic floor and sidewalk blocks are fully illustrated and explained. (No. 2 of Series) Price . . . . . . **50 cents**

ctical Concrete Silo Construction. By A. A. HOUGHTON.

Complete working drawings and specifications are given for several styles of concrete silos, with illustrations of molds for monolithic and block silos. The tables, data, and information presented in this book are of the utmost value in planning and constructing all forms of concrete silos. (No. 3 of Series) Price . . . . **50 cents**

Molding Concrete Chimneys, Slate and Roof Tiles. By A. A. H

The manufacture of all types of concrete slate and roof tile is fully treated. on all forms of reinforced concrete roofs are contained within its pages. Th of concrete chimneys by block and monolithic systems is fully illustrated and number of ornamental designs of chimney construction with molds are shown i treatise. (No. 4 of Series.) Price . . . .

Molding and Curing Ornamental Concrete. By A. A. Houghт

The proper proportions of cement and aggregates for various finishes, also thoroughly mixing and placing in the molds, are fully treated. An exhaust this subject that every concrete worker will find of daily use and value. (N Price . . . .

Concrete Monuments, Mausoleums and Burial Vaults. By A. A.

The molding of concrete monuments to imitate the most expensive cut sto in this treatise, with working drawings of easily built molds. Cutting inscri signs are also fully treated. (No. 6 of Series.) Price . . . .

Molding Concrete Bathtubs, Aquariums and Natatoriums. Houghton.

Simple molds and instruction are given for molding many styles of concrete b ming-pools, etc. These molds are easily built and permit rapid and successful of Series.) Price . . . .

Concrete Bridges, Culverts and Sewers. By A. A. Houghton.

A number of ornamental concrete bridges with illustrations of molds are given. center or core for bridges, culverts and sewers is fully illustrated with detail for building. (No. 8 of Series.) Price . . . .

Constructing Concrete Porches. By A. A. Houghton.

A number of designs with working drawings of molds are fully explained so any construct different styles of ornamental concrete porches without the purchas molds. (No. 9 of Series.) Price . . . .

Molding Concrete Flower-Pots, Boxes, Jardinieres, Etc. By A. A.

The molds for producing many original designs of flower-pots, urns, flower-box etc., are fully illustrated and explained, so the worker can easily construct and (No. 10 of Series.) Price . . . .

Molding Concrete Fountains and Lawn Ornaments. By A. A.

The molding of a number of designs of lawn seats, curbing, hitching posts, per and other forms of ornamental concrete for the ornamentation of lawns and g illustrated and described. (No. 11 of Series.) Price . . . .

Concrete from Sand Molds. By A. A. Houghton.

A Practical Work treating on a process which has heretofore been held as a the few who possessed it, and which will successfully mold every and any class concrete work. The process of molding concrete with sand molds is of the u value, possessing the manifold advantages of a low cost of molds, the ease operation, perfect details to all ornamental designs, density and increased concrete, perfect curing of the work without attention and the easy remova regardless of any undercutting the design may have. 192 pages. F Price . . . .

namental Concrete without Molds. By A. A. HOUGHTON.

The process for making ornamental concrete without molds has long been held as a secret, and now, for the first time, this process is given to the public. The book reveals the secret and is the only book published which explains a simple, practical method whereby the concrete worker is enabled, by employing wood and metal templates of different designs, to mold or model in concrete any Cornice, Archivolt, Column, Pedestal, Base Cap, Urn or Pier in a monolithic form—right upon the job. These may be molded in units or blocks and then built up to suit the specifications demanded. This work is fully illustrated, with detailed engravings. Price **$2.00**

ncrete for the Farm and in the Shop. By H. COLIN CAMPBELL, C.E., E.M.

"Concrete for the Farm and in the Shop" is a new book from cover to cover, illustrating and describing in plain, simple language many of the numerous applications of concrete within the range of the home worker. Among the subjects treated are: Principles of Reinforcing; Methods of Protecting Concrete so as to Insure Proper Hardening; Home-made Mixers; Mixing by Hand and Machine; Form Construction, Described and Illustrated by Drawings and Photographs; Construction of Concrete Walls and Fences; Concrete Fence Posts; Concrete Gate Posts; Corner Posts; Clothes Line Posts; Grape Arbor Posts; Tanks; Troughs; Cisterns; Hog Wallows; Feeding Floors and Barnyard Pavements; Foundations; Well Curbs and Platforms; Indoor Floors; Sidewalks; Steps; Concrete Hotbeds and Cold Frames; Concrete Slab Roofs; Walls for Buildings; Repairing Leaks in Tanks and Cisterns; and all topics associated with these subjects as bearing upon securing the best results from concrete are dwelt upon at sufficient length in plain every-day English so that the inexperienced person desiring to undertake a piece of concrete construction can, by following the directions set forth in this book, secure 100 per cent. success every time. A number of convenient and practical tables for estimating quantities, and some practical examples, are also given. (5x7.) 149 pages. 51 illustrations. Price . . . . **75 cents**

pular Handbook for Cement and Concrete Users. By MYRON H. LEWIS.

This is a concise treatise of the principles and methods employed in the manufacture and use of cement in all classes of modern works. The author has brought together in this work all the salient matter of interest to the user of concrete and its many diversified products. The matter is presented in logical and systematic order, clearly written, fully illustrated and free from involved mathematics. Everything of value to the concrete user is given, including kinds of cement employed in construction, concrete architecture, inspection and testing, waterproofing, coloring and painting, rules, tables, working and cost data. The book comprises thirty-three chapters, as follow: Introductory. Kinds of Cement and How They are Made. Properties. Testing and Requirements of Hydraulic Cement. Concrete and Its Properties. Sand, Broken Stone and Gravel for Concrete. How to Proportion the Materials. How to Mix and Place Concrete. Forms of Concrete Construction. The Architectural and Artistic Possibilities of Concrete. Concrete Residences. Mortars, Plasters and Stucco, and How to Use Them. The Artistic Treatment of Concrete Surfaces. Concrete Building Blocks. The Making of Ornamental Concrete. Concrete Pipes, Fences, Posts, etc. Essential Features and Advantages of Reenforced Concrete. How to Design Reenforced Concrete Beams, Slabs and Columns. Explanations of the Methods and Principles in Designing Reenforced Concrete, Beams and Slabs. Systems of Reenforcement Employed. Reenforced Concrete in Factory and General Building Construction. Concrete in Foundation Work. Concrete Retaining Walls, Abutments and Bulkheads. Concrete Arches and Arch Bridges. Concrete Beam and Girder Bridges. Concrete in Sewerage and Draining Works. Concrete Tanks, Dams and Reservoirs. Concrete Sidewalks, Curbs and Pavements. Concrete in Railroad Construction. The Utility of Concrete on the Farm. The Waterproofing of Concrete Structures. Grout of Liquid Concrete and Its Use. Inspection of Concrete Work. Cost of Concrete Work. Some of the special features of the book are: 1.—The Attention Paid to the Artistic and Architectural Side of Concrete Work. 2.—The Authoritative Treatment of the Problem of Waterproofing Concrete. 3.—An Excellent Summary of the Rules to be Followed in Concrete Construction. 4.—The Valuable Cost Data and Useful Tables given. A valuable Addition to the Library of Every Cement and Concrete User. Price . **$2.50**

terproofing Concrete. By MYRON H. LEWIS.

Modern Methods of Waterproofing Concrete and Other Structures. A condensed statement of the Principles, Rules, and Precautions to be Observed in Waterproofing and Dampproofing Structures and Structural Materials. Paper binding. Illustrated. Price . . . . **50 cents**

DICTIONARIES

Aviation Terms, Termes D'Aviation, English-French, Frenc
Compiled by Lieuts. VICTOR W. PAGÉ, A.S., S.C.U.S.R., and I
TARIOL, of the French Flying Corps, on duty on Signal Corps Avia
Mineola, L. I.

The lists contained are confined to essentials, and special folding plates are inc all important airplane parts. The lists are divided in four sections as follow Field Terms. 2.—The Airplane. 3.—The Engine. 4.—Tools and Shop Term A complete, well illustrated volume intended to facilitate conversation between I ing and French aviators. A very valuable book for all who are about to leave seas.
Approved for publication by Major W. G. Kilner, S.C., U.S.C.O. Signal Corps Av Hazelhurst Field, Mineola, L. I. This book should be in every Aviator's and M for ready reference. 128 pages, fully illustrated, with detailed engravings. Pr

Standard Electrical Dictionary. By T. O'CONOR SLOANE.

An indispensable work to all interested in electrical science. Suitable alike fo and professional. A practical handbook of reference containing definitions o distinct words, terms and phrases. The definitions are terse and concise and term used in electrical science. Recently issued. An entirely new edition. the possession of all who desire to keep abreast with the progress of this bran Complete, concise and convenient. 682 pages, 393 illustrations. Price . . . .

DIES—METAL WORK

Dies: Their Construction and Use for the Modern Working of She
By J. V. WOODWORTH.

A most useful book, and one which should be in the hands of all engaged in the of metals; treating on the Designing, Constructing, and Use of Tools, Fixtures together with the manner in which they should be used in the Power Press, for rapid production of the great variety of sheet-metal articles now in use. as a guide to the production of sheet-metal parts at the minimum of maximum of output. The hardening and tempering of Press tools and the cl which may be produced to the best advantage by the use of dies in the power treated. Its 515 illustrations show dies, press fixtures and sheet-metal workin descriptions of which are so clear and practical that all metal-working mechani to understand how to design, construct and use them. Many of the dies and treated were either constructed by the author or under his supervision. Others skilful mechanics and are in use in large sheet-metal establishments and m 6th Revised and Enlarged Edition. Price . . . .

Punches, Dies and Tools for Manufacturing in Presses. By J.
WORTH.

This work is a companion volume to the author's elementary work entitled ' Construction and Use." It does not go into the details of die-making to the author's previous book, but gives a comprehensive review of the field of operati by presses. A large part of the information given has been drawn from the aut experience. It might well be termed an Encyclopedia of Die-Making, Punch-Sinking, Sheet-Metal Working, and Making of Special Tools, Sub-presses, Devices cal Combinations for Punching, Cutting, Bending, Forming, Piercing, Drawing, and Assembling Sheet-Metal Parts, and also Articles of other Materials in M 2d Edition. Price . . . .

p Forging, Die-Sinking and Machine-Forming of Steel. By J. V. WOODWORTH.

This is a practical treatise on Modern Shop Practice, Processes, Methods, Machine Tools, and Details treating on the Hot and Cold Machine-Forming of Steel and Iron into Finished Shapes: together with Tools, Dies, and Machinery involved in the manufacture of Duplicate Forgings and Interchangeable Hot and Cold Pressed Parts from Bar and Sheet Metal. This book fills a demand of long standing for information regarding drop-forgings, die-sinking and machine-forming of steel and the shop practice involved, as it actually exists in the modern drop-forging shop. The processes of die-sinking and force-making, which are thoroughly described and illustrated in this admirable work, are rarely to be found explained in such a clear and concise manner as is here set forth. The process of die-sinking relates to the engraving or sinking of the female or lower dies, such as are used for drop-forgings, hot and cold machine-forging, swedging, and the press working of metals. The process of force-making relates to the engraving or raising of the male or upper dies used in producing the lower dies for the press-forming and machine-forging of duplicate parts of metal.
In addition to the arts above mentioned the book contains explicit information regarding the drop-forging and hardening plants, designs, conditions, equipment, drop hammers, forging machines, etc., machine forging, hydraulic forging, autogenous welding and shop practice. The book contains eleven chapters, and the information contained in these chapters is just what will prove most valuable to the forged-metal worker. All operations described in the work are thoroughly illustrated by means of perspective half-tones and outline sketches of the machinery employed. 300 detailed illustrations. Price **$2.50**

DRAWING—SKETCHING PAPER

ctical Perspective. By RICHARDS and COLVIN.

Shows just how to make all kinds of mechanical drawings in the only practical perspective isometric. Makes everything plain, so that any mechanic can understand a sketch or drawing in this way. Saves time in the drawing room, and mistakes in the shops. Contains practical examples of various classes of work. 4th Edition. Price . . . . **50 cents**

ear Perspective Self-Taught. By HERMAN T. C. KRAUS.

This work gives the theory and practice of linear perspective, as used in architectural, engineering and mechanical drawings. Persons taking up the study of the subject by themselves will be able, by the use of the instruction given, to readily grasp the subject, and by reasonable practice become good perspective draftsmen. The arrangement of the book is good; the plate is on the left-hand, while the descriptive text follows on the opposite page, so as to be readily referred to. The drawings are on sufficiently large scale to show the work clearly and are plainly figured. There is included a self-explanatory chart which gives all information necessary for the thorough understanding of perspective. This chart alone is worth many times over the price of the book. 2d Revised and Enlarged Edition. Price **$2.50**

f-Taught Mechanical Drawing and Elementary Machine Design. By F. L. SYLVESTER, M.E., Draftsman, with additions by ERIK OBERG, associate editor of "Machinery."

This is a practical treatise on Mechanical Drawing and Machine Design, comprising the first principles of geometric and mechanical drawing, workshop mathematics, mechanics, strength of materials and the calculations and design of machine details. The author's aim has been to adapt this treatise to the requirements of the practical mechanic and young draftsman and to present the matter in as clear and concise a manner as possible. To meet the demands of this class of students, practically all the important elements of machine design have been dealt with, and in addition algebraic formulas have been explained, and the elements of trigonometry treated in the manner best suited to the needs of the practical man. The book is divided into 20 chapters, and in arranging the material, mechanical drawing, pure and simple, has been taken up first, as a thorough understanding of the principles of representing objects facilitates the further study of mechanical subjects. This is followed by the mathematics necessary for the solution of the problems in machine design which are presented later, and a practical introduction to theoretical mechanics and the strength of materials. The various elements entering into machine design, such as cams, gears, sprocket-wheels, cone pulleys, bolts, screws, couplings, clutches, shafting and fly-wheels, have been treated in such a way as to make possible the use of the work as a text-book for a continuous course of study. It is easily comprehended and assimilated even by students of limited previous training. 330 pages, 215 engravings. Price **$2.00**

A New Sketching Paper.

A new specially ruled paper to enable you to mak
tive without any figuring or fussing. It is being
drawings, as it makes one sketch do the work of
what is wanted.

Pads of 40 sheets, 6x9 inches. Price . . .
Pads of 40 sheets, 9x12 inches. Price . . .
40 sheets, 12x18 inches. Price . . . .

ELECTRIC

Arithmetic of Electricity. By Prof. T. O'

A practical treatise on electrical calculations of all
simplest forms, and involving only ordinary arith
practical problems, with detailed solution of each
useful works published on the science of electrici
electricity in a manner that will attract the attent
braical formulas. 20th Edition. 160 pages. Pr

Commutator Construction. By Wm. Baxt

The business end of any dynamo or motor of the d
book goes into the designing, building, and maint
troubles and how to remedy them; everyone who f
Price . . . .

Dynamo Building for Amateurs, or How to
By Arthur J. Weed, Member of N. Y

A practical treatise showing in detail the construc
machine work of which can be done on a small
are given for each piece of machine work, and
machine, when used as a dynamo, has an output
drive a small drill press or lathe. It can be used
ordinary work. The book is illustrated with more
actual construction of the different parts. Among
Dynamo. 2. Side Bearing Rods. 3. Field Pu
Pulley. 7. Brush Holders. 8. Connection Bo
11. Armature Winding. 12. Field Winding. 1
Paper. Price . . . .
Cloth. Price . . . .

Electric Bells. By M. B. Sleeper.

A complete treatise for the practical worker in Ins
Burglar Alarms, Thermostats, and other apparatu
Both the electrician and the experimenter will find
in their work. Tools, bells, batteries, unusual ci
thermostats, circuit breakers, time alarms, and o
scribed from the standpoints of their applicati
instruction for building the apparatus will appeal
The practical worker will find the chapter on Wi
Winding, Upkeep of Systems, and the Location o
Among the chapters are: Tools and Materials
Batteries for Small Installations; Making Bells
Construction of Annunciators and Signals; Burgl
Elaborate Bell Systems; Finding Faults and Rem
Price . . . .

tric Lighting and Heating Pocket Book. By SYDNEY F. WALKER.

This book puts in convenient form useful information regarding the apparatus which is likely to be attached to the mains of an electrical company. Tables of units and equivalents are included and useful electrical laws and formulas are stated. 438 pages, 300 engravings. Bound in leather. Pocket book form. Price **$3.00**

tric Wiring, Diagrams and Switchboards. By NEWTON HARRISON, with additions by THOMAS POPPE.

A thoroughly practical treatise covering the subject of Electric Wiring in all its branches, including explanations and diagrams which are thoroughly explicit and greatly simplify the subject. Practical, every-day problems in wiring are presented and the method of obtaining intelligent results clearly shown. Only arithmetic is used. Ohm's law is given a simple explanation with reference to wiring for direct and alternating currents. The fundamental principle of drop of potential in circuits is shown with its various applications. The simple circuit is developed with the position of mains, feeders and branches; their treatment as a part of a wiring plan and their employment in house wiring clearly illustrated. Some simple facts about testing are included in connection with the wiring. Molding and conduit work are given careful consideration; and switchboards are systematically treated, built up and illustrated, showing the purpose they serve, for connection with the circuits, and to shunt and compound wound machines. The simple principles of switchboard construction, the development of the switchboard, the connections of the various instruments, including the lightning arrester, are also plainly set forth.
Alternating current wiring is treated, with explanations of the power factor, conditions calling for various sizes of wire, and a simple way of obtaining the sizes for single-phase, two-phase and three-phase circuits. This is the only complete work issued showing and telling you what you should know about direct and alternating current wiring. It is a ready reference. The work is free from advanced technicalities and mathematics, arithmetic being used throughout. It is in every respect a handy, well-written, instructive, comprehensive volume on wiring for the wireman, foreman, contractor, or electrician. 2nd Revised Edition. 303 pages, 130 illustrations. Price **$1.50**

ctric Furnaces and their Industrial Applications. By J. WRIGHT.

This is a book which will prove of interest to many classes of people; the manufacturer who desires to know what product can be manufactured successfully in the electric furnace, the chemist who wishes to post himself on the electro-chemistry, and the student of science who merely looks into the subject from curiosity. New, Revised and Enlarged Edition. 320 pages. Fully illustrated, cloth. Price **$3.00**

ctric Toy Making, Dynamo Building, and Electric Motor Construction. By Prof. T. O'CONOR SLOANE.

This work treats of the making at home of electrical toys, electrical apparatus, motors, dynamos, and instruments in general, and is designed to bring within the reach of young and old the manufacture of genuine and useful electrical appliances. The work is especially designed for amateurs and young folks.
Thousands of our young people are daily experimenting, and busily engaged in making electrical toys and apparatus of various kinds. The present work is just what is wanted to give the much needed information in a plain, practical manner, with illustrations to make easy the carrying out of the work. 20th Edition. Price **$1.00**

ctricity Simplified. By Prof. T. O'CONOR SLOANE.

The object of "Electricity Simplified" is to make the subject as plain as possible and to show what the modern conception of electricity is; to show how two plates of different metal, immersed in acid, can send a message around the globe; to explain how a bundle of copper wire rotated by a steam engine can be the agent in lighting our streets, to tell what the volt, ohm and ampere are, and what high and low tension mean; and to answer the questions that perpetually arise in the mind in this age of electricity. 13th Edition. 172 pages. Illustrated. Price **$1.00**

House Wiring. By THOMAS W. POPPE.

This work describes and illustrates the actual inst ner in which the work should be done, and the m veniently carried in the pocket. It is intended f It solves all Wiring Problems and contains noth National Board of Fire Underwriters. It gives ju ful Wiring of a Building. Among the subjects Boards. Switches. Plug Receptacles. Brackets tions. The Feed Wires. The Steel Armored C System. The Ridig Conduit System. A digest o rules relating to metallic wiring systems. Vari diagrammed. The easiest method of testing th The grounding of all metallic wiring systems and t The insulation of the metal parts of lamp fixtures illustrated. 125 pages. 2nd Edition, revised a cloth. Price . . . .

How to Become a Successful Electrician.

Every young man who wishes to become a succe tells in simple language the surest and easiest wa studies to be followed, methods of work, field of cessful electrician are pointed out and fully explain excellent stepping stone to more advanced works success can be attained. Many young men becor tempting to read and study books that are far beyo as the connecting link between the rudiments taug of electricity. It is interesting from cover to cove pages. Illustrated. Price . . . .

Management of Dynamos. By LUMMIS-PA

A handbook of theory and practice. This work covers the elementary theory of the dynamo. Th of the different classes of dynamos in common use to such matters as affect the practical managem 4th Edition. 292 pages, 117 illustrations. Price

Practical Electricity. By Prof. T. O'CONOR

This work of 768 pages was previously known a intended for the practical electrican who has to ma is covered within its pages. Among some of the Electric Current and Circuit, Electro-Chemistr Generation and Utilization of Electric Powers, Dynamos and Motors, Motor Generators, Opera Safety Appliances, Distribution of Electric Light Arc and Incandescent Lighting, Electric Meas Telephony, Bell-Wiring, Electric-Plating, Electri contains no useless theory; everything is to the to know about electricity. It is the standard w chapters, 556 engravings. Price . . . .

Switchboards. By WILLIAM BAXTER, JR.

This book appeals to every engineer and electric of things. It takes up all sorts and conditions shows by diagram and illustration just how the s direct and alternating current boards, also those circuits. Special treatment on high voltage boa 190 pages, Illustrated. Price . . . .

ndard Electrical Dictionary. By T. O'CONOR SLOANE.

An indispensable work to all interested in electrical science. Suitable alike for the student and professional. A practical handbook of reference containing definitions of about 5,000 distinct words, terms and phrases. The definitions are terse and concise and include every term used in electrical science. Recently issued. An entirely new edition. Should be in the possession of all who desire to keep abreast with the progress of this branch of science. In its arrangement and typography the book is very convenient. The word or term defined is printed in black-faced type, which readily catches the eye, while the body of the page is in smaller but distinct type. The definitions are well worded, and so as to be understood by the non-technical reader. The general plan seems to be to give an exact, concise definition, and then amplify and explain in a more popular way. Synonyms are also given, and references to other words and phrases are made. A very complete and accurate index of fifty pages is at the end of the volume; and as this index contains all synonyms, and as all phrases are indexed in every reasonable combination of words, reference to the proper place in the body of the book is readily made. It is difficult to decide how far a book of this character is to keep the dictionary form, and to what extent it may assume the encyclopedia form. For some purposes, concise, exactly worded definitions are needed; for other purposes, more extended descriptions are required. This book seeks to satisfy both demands, and does it with considerable success. 682 pages, 393 illustrations. 12th Edition.
Price **$3.00**

rage Batteries Simplified. By VICTOR W. PAGÉ, M.E.

A complete treatise on storage battery operating principles, repairs and applications. The greatly increasing application of storage batteries in modern engineering and mechanical work has created a demand for a book that will consider this subject completely and exclusively. This is the most thorough and authoritative treatise ever published on this subject. It is written in easily understandable, non-technical language so that any one may grasp the basic principles of storage battery action as well as their practical industrial applications. All electric and gasoline automobiles use storage batteries. Every automobile repairman, dealer or salesman should have a good knowledge of maintenance and repair of these important elements of the motor car mechanism. This book not only tells how to charge, care for and rebuild storage batteries but also outlines all the industrial uses. Learn how they run street cars, locomotives and factory trucks. Get an understanding of the important functions they perform in submarine boats, isolated lighting plants, railway switch and signal systems, marine applications, etc. This book tells how they are used in central station standby service, for starting automobile motors and in ignition systems. Every practical use of the modern storage battery is outlined in this treatise. 320 pages, fully illustrated. Price . . . **$1.50**

lephone Construction, Installation, Wiring, Operation and Maintenance. By W. H. RADCLIFFE and H. C. CUSHING.

This book is intended for the amateur, the wireman, or the engineer who desires to establish a means of telephonic communication between the rooms of his home, office, or shop. It deals only with such things as may be of use to him rather than with theories.
Gives the principles of construction and operation of both the Bell and Independent instruments; approved methods of installing and wiring them; the means of protecting them from lightning and abnormal currents; their connection together for operation as series or bridging stations; and rules for their inspection and maintenance. Line wiring and the wiring and operation of special telephone systems are also treated. Intricate mathematics are avoided, and all apparatus, circuits and systems are thoroughly described. The appendix contains definitions of units and terms used in the text. Selected wiring tables, which are very helpful, are also included. Among the subjects treated are Construction, Operation, and Installation of Telephone Instruments; Inspection and Maintenance of Telephone Instruments, Telephone Line Wiring; Testing Telephone Line Wires and Cables; Wiring and Operation of Special Telephone Systems, etc. 2nd Edition, Revised and Enlarged. 223 pages, 154 illustrations **$1.00**

ring a House. By HERBERT PRATT.

Shows a house already built; tells just how to start about wiring it; where to begin; what wire to use; how to run it according to Insurance Rules; in fact, just the information you need. Directions apply equally to a shop. 4th Edition. Price . . . . **25 cents**

Wireless Telegraphy and Telephony Sin
MORGAN.

This is undoubtedly one of the most complete a
ever published, and a close study of its pages wil
wireless transmission of messages. The author h
in furnishing a lucid, comprehensible explanation i
of wireless telegraphy and telephony.
Among the contents are: Introductory; Wireles
System, Earth Connections—The Transmitting
Condensers, Helixes, Spark Gaps, Anchor Gaps,
Detectors, etc.—Tuning and Coupling, Tuning C
Directive Wave Systems—Miscellaneous Apparat
Static Interference—Wireless Telephones, Sound
Ear—Wireless Telephone, How Sounds Are Ch
phones, The Apparatus—Summary. 154 pages, 1

FACTORY MANAGE

Modern Machine Shop Construction, Equ
O. E. PERRIGO, M.E.

The only work published that describes the mod
from the time the grass is growing on the site i
shipped. By a careful study of its thirty-two ch
build, efficiently equip, and successfully manage t
establishment. Just the book needed by those
buildings, the rebuilding and reorganization of ol
methods, time and cost systems. It is a book
man for practical shop men who are too busy to
complete all-around book of its kind ever publishe
from the apprentice in the shop to the president
lustrates the most simple and yet the most effici
Revised and Enlarged Edition, just issued. 384 p

FUEL

Combustion of Coal and the Prevention

This book has been prepared with special refere
bustion of the common fuels found in the United
ditions necessary to the economic and smokeless c
and Locomotive Steam Boilers.
The presentation of this important subject is syst
of the book is in a series of practical questions to
describe in language, free from technicalities, the
combustion of American fuels; it clearly states th
and points out the best methods for furnace cons
of heat from any given quality of coal. Nearly 350

Smoke Prevention and Fuel Economy.

A complete treatise for all interested in smoke p
the German work of Ernst Schmatolla, but it is n
treatise, much being added. The authors show
combustion, the methods which have been and a
scientific methods for obtaining all the energy i
Considerable space is also given to the examinat
representative English and American mechanical
The losses carried away in the waste gases are th
pendix, and abstracts are also here given of vari
book is complete and contains much of value to all
Illustrated. Price . . . .

GAS ENGINES AND GAS

I, Gasoline and Oil Engines. By GARDNER D. HISCOX. Revised by VICTOR W. PAGÉ, M.E.

Just issued New 1918 Edition, Revised and Enlarged. Every user of a gas engine needs this book. Simple, instructive and right up-to-date. The only complete work on the subject. Tells all about internal combustion engineering, treating exhaustively on the design, construction and practical application of all forms of gas, gasoline, kerosene and crude petroleum-oil engines. Describes minutely all auxiliary systems, such as lubrication, carburetion and ignition. Considers the theory and management of all forms of explosive motors for stationary and marine work, automobiles, aeroplanes and motor-cycles. Includes also Producer Gas and Its Production. Invaluable instructions for all students, gas-engine owners, gas-engineers, patent experts, designers, mechanics, draftsmen and all having to do with the modern power Illustrated by over 400 engravings, many specially made from engineering drawings, all in correct proportion. 650 pages, 435 engravings. Price . . . . **$2.50 net**

e Gasoline Engine on the Farm: Its Operation, Repair and Uses. By XENO W. PUTNAM.

This is a practical treatise on the Gasoline and Kerosene Engine intended for the man who wants to know just how to manage his engine and how to apply it to all kinds of farm work to the best advantage.

This book abounds with hints and helps for the farm and suggestions for the home and housewife. There is so much of value in this book that it is impossible to adequately describe it in such small space. Suffice to say that it is the kind of a book every farmer will appreciate and every farm home ought to have. Includes selecting the most suitable engine for farm work, its most convenient and efficient installation, with chapters on troubles, their remedies, and how to avoid them. The care and management of the farm tractor in plowing, harrowing, harvesting and road grading are fully covered; also plain directions are given for handling the tractor on the road. Special attention is given to relieving farm life of its drudgery by applying power to the disagreeable small tasks which must otherwise be done by hand. Many home-made contrivances for cutting wood, supplying kitchen, garden, and barn with water, loading, hauling and unloading hay, delivering grain to the bins or the feed trough are included; also full directions for making the engine milk the cows, churn, wash, sweep the house and clean the windows, etc. Very fully illustrated with drawings of working parts and cuts showing Stationary, Portable and Tractor Engines doing all kinds of farm work. All money-making farms utilize power. Learn how to utilize power by reading the pages of this book. It is an aid to the result getter, invaluable to the up-to-date farmer, student, blacksmith, implement dealer and, in fact, all who can apply practical knowledge of stationary gasoline engines or gas tractors to advantage. 530 pages. Nearly 180 engravings. Price **$2.00**

WHAT IS SAID OF THIS BOOK:

"Am much pleased with the book and find it to be very complete and up-to-date. I will heartily recommend it to students and farmers whom I think would stand in need of such a work, as I think it is an exceptionally good one."—*N. S. Gardiner*, Prof. in Charge, Clemson Agr. College of S. C.; Dept. of Agri. and Agri. Exp. Station, Clemson College, S. C.

"I feel that Mr. Putnam's book covers the main points which a farmer should know."—*R. T. Burdick*, Instructor in Agronomy, University of Vermont, Burlington, Vt.

soline Engines: Their Operation, Use and Care. By A. HYATT VERRILL.

The simplest, latest and most comprehensive popular work published on Gasoline Engines, describing what the Gasoline Engine is; its construction and operation; how to install it; how to select it; how to use it and how to remedy troubles encountered. Intended for Owners, Operators and Users of Gasoline Motors of all kinds. This work fully describes and illustrates the various types of Gasoline Engines used in Motor Boats, Motor Vehicles and Stationary Work. The parts, accessories and appliances are described with chapters on ignition, fuel, lubrication, operation and engine troubles. Special attention is given to the care, operation and repair of motors, with useful hints and suggestions on emergency repairs and makeshifts. A complete glossary of technical terms and an alphabetically arranged table of troubles and their symptoms form most valuable and unique features of this manual. Nearly every illustration in the book is original, having been made by the author. Every page is full of interest and value. A book which you cannot afford to be without. 275 pages, 152 specially made engravings. Price **$1.50**

Gas Engine Construction, or How to Build a Half-horsepower Gas
By Parsell and Weed.

A practical treatise of 300 pages describing the theory and principles of the act Engines of various types and the design and construction of a half-horsepower C with illustrations of the work in actual progress, together with the dimensioned wo ings, giving clearly the sizes of the various details; for the student, the scientific i and the amateur mechanic. This book treats of the subject more from the st practice than that of theory. The principles of operation of Gas Engines are simply described, and then the actual construction of a half-horsepower engine i step by step, showing in detail the making of the Gas Engine. 3rd Edition. Price . . . .

How to Run and Install Two- and Four-Cycle Marine Gasoline
By C. Von Culin.

Revised and enlarged edition just issued. The object of this little book is to furn instructor for the beginner, the busy man who uses an engine for pleasure or prof does not have the time or inclination for a technical book, but simply to thorou stand how to properly operate, install and care for his own engine. The index re trouble, remedy, and subject alphabetically. Being a quick reference to find the ca and prevention for troubles, and to become an expert with his own engine. I Paper binding. Price . . . .

Modern Gas Engines and Producer Gas Plants. By R. E. Mathot.

A guide for the gas engine designer, user, and engineer in the construction, selectio installation, operation, and maintenance of gas engines. More than one book on has been written, but not one has thus far even encroached on the field covered b Above all, Mr. Mathot's work is a practical guide. Recognizing the need of a v would assist the gas engine user in understanding thoroughly the motor upon which for power, the author has discussed his subject without the help of any mathematic out elaborate theoretical explanations. Every part of the gas engine is describe tersely, clearly, with a thorough understanding of the requirements of the mecha ful suggestions as to the purchase of an engine, its installation, care, and operat most valuable feature of the work. 320 pages, 175 detailed illustrations. Price .

The Modern Gas Tractor. By Victor W. Pagé, M.E.

A complete treatise describing all types and sizes of gasoline, kerosene and oil trac siders design and construction exhaustively, gives complete instructions for care, op repair, outlines all practical applications on the road and in the field. The best work on farm tractors and tractor power plants. A work needed by farmers, stud smiths, mechanics, salesmen, implement dealers, designers and engineers. 2nd E vised. 504 pages, 228 illustrations, 3 folding plates. Price . . . .

GEARING AND CAMS

Change Gear Devices. By Oscar E. Perrigo.

A practical book for every designer, draftsman, and mechanic interested in the inv development of the devices for feed changes on the different machines requiring such All the necessary information on this subject is taken up, analyzed, classified, sifte centrated for the use of busy men who have not the time to go through the masses o matter with which such a subject is usually encumbered and select such informa be useful to them.

It shows just what has been done, how it has been done, when it was done, and It saves time in hunting up patent records and re-inventing old ideas. 88 pages. Price . . . .

Drafting of Cams. By Louis Rouillion.

The laying out of cams is a serious problem unless you know how to go at it right. you on the right road for practically any kind of cam you are likely to run up a Edition. Price . . . .

Gear Tables. By D. Ag. Engstrom.

A book that will at once commend itself to mechanics and draftsmen. Does away with all the trigonometry and fancy figuring on bevel gears, and makes it easy for anyone to lay them out or make them just right. There are 36 full-page tables that show every necessary dimension for all sizes or combinations you're apt to need. No puzzling, figuring or guessing. Gives placing distance, all the angles (including cutting angles), and the correct cutter to use. A copy of this prepares you for anything in the bevel-gear line. 3rd Edition. 66 pages. Price **$1.00**

HYDRAULICS

raulic Engineering. By Gardner D. Hiscox.

A treatise on the properties, power, and resources of water for all purposes. Including the measurement of streams, the flow of water in pipes or conduits; the horsepower of falling water, turbine and impact water-wheels, wave motors, centrifugal, reciprocating and air-lift pumps. With 300 figures and diagrams and 36 practical tables. All who are interested in water-works development will find this book a useful one, because it is an entirely practical treatise upon a subject of present importance and cannot fail in having a far-reaching influence, and for this reason should have a place in the working library of every engineer. Among the subjects treated are: Historical Hydraulics; Properties of Water; Measurement of the Flow of Streams; Flow from Sub-surface Orifices and Nozzles; Flow of Water in Pipes; Siphons of Various Kinds; Dams and Great Storage Reservoirs; City and Town Water Supply; Wells and Their Reinforcement; Air-lift Methods of Raising Water; Artesian Wells; Irrigation of Arid Districts; Water Power; Water Wheels; Pumps and Pumping Machinery; Reciprocating Pumps; Hydraulic Power Transmission; Hydraulic Mining; Canals; Ditches; Conduits and Pipe Lines; Marine Hydraulics; Tidal and Sea Wave Power, etc. 320 pages. Price . . . **$4.00**

ICE AND REFRIGERATION

ketbook of Refrigeration and Ice Making. By A. J. Wallis-Taylor.

This is one of the latest and most comprehensive reference books published on the subject of refrigeration and cold storage. It explains the properties and refrigerating effect of the different fluids in use, the management of refrigerating machinery and the construction and insulation of cold rooms with their required pipe surface for different degrees of cold; freezing mixtures and non-freezing brines, temperatures of cold rooms for all kinds of provisions, cold storage charges for all classes of goods, ice making and storage of ice, data and memoranda for constant reference by refrigerating engineers, with nearly one hundred tables containing valuable references to every fact and condition required in the installment and operation of a refrigerating plant. New edition just published. Price **$1.50**

INVENTIONS—PATENTS

rentors' Manual: How to Make a Patent Pay.

This is a book designed as a guide to inventors in perfecting their inventions, taking out their patents and disposing of them. It is not in any sense a Patent Solicitor's Circular nor a Patent Broker's Advertisement. No advertisements of any description appear in the work. It is a book containing a quarter of a century's experience of a successful inventor, together with notes based upon the experience of many other inventors.
Among the subjects treated in this work are: How to Invent. How to Secure a Good Patent. Value of Good Invention. How to Exhibit an Invention. How to Interest Capital. How to Estimate the Value of a Patent. Value of Design Patents. Value of Foreign Patents. Value of Small Inventions. Advice on Selling Patents. Advice on the Formation of Stock Companies. Advice on the Formation of Limited Liability Companies. Advice on Disposing of Old Patents. Advice as to Patent Attorneys. Advice as to Selling Agents. Forms of Assignments. License and Contracts. State Laws Concerning Patent Rights. 1900 Census of the United States by Counts of Over 10,000 Population. Revised Edition. 120 pages. Price **$1.00**

KNOTS

Knots, Splices and Rope Work. By A. Hyatt Verrill.

This is a practical book giving complete and simple directions for making all and ornamental knots in common use, with chapters on Splicing, Pointing, etc. This book is fully illustrated with 154 original engravings, which show tie or splice is formed, and its appearance when finished. The book will be fou value to Campers, Yachtsmen, Travelers, Boy Scouts, in fact, to anyone ha use or handle rope or knots for any purpose. The book is thoroughly reliab and is not only a guide, but a teacher. It is the standard work on the subj contents are: 1. Cordage, Kinds of Rope. Construction of Rope, Parts of Bolt Rope. Strength of Rope, Weight of Rope. 2. Simple Knots and Ben in Handling Rope. Seizing Rope. 3. Ties and Hitches. 4. Noose, Loo Knots. 5. Shortenings, Grommets and Salvages. 6. Lashings, Seizings Fancy Knots and Rope Work. 128 pages, 150 original engravings. 2nd Price . . . .

LATHE WORK

Lathe Design, Construction, and Operation, with Practical Lathe Work. By Oscar E. Perrigo.

A new, revised edition, and the only complete American work on the subje man who knows not only how work ought to be done, but who also knows h how to convey this knowledge to others. It is strictly up-to-date in its illustrations. Lathe history and the relations of the lathe to manufactu also a description of the various devices for feeds and thread-cutting mecha efforts in this direction to the present time. Lathe design is thoroughly d ing back gearing, driving cones, thread-cutting gears, and all the essential modern lathe. The classification of lathes is taken up, giving the essenti the several types of lathes including, as is usually understood, engine lath speed lathes, forge lathes, gap lathes, pulley lathes, forming lathes, multip rapid-reduction lathes, precision lathes, turret lathes, special lathes, electrical etc. In addition to the complete exposition on construction and design, matter on lathe installation, care and operation has been incorporated in t edition. All kinds of lathe attachments for drilling, milling, etc., are des plete instructions are given to enable the novice machinist to grasp the art o as well as the principles involved in design. A number of difficult mach are described at length and illustrated. The new edition has nearly 500 pag trations. Price . . . .

WHAT IS SAID OF THIS BOOK:

"This is a lathe book from beginning to end, and is just the kind of a boo lights to consult—a masterly treatment of the subject in hand."—*Engineeri*

"This work will be of exceptional interest to any one who is interested in l one very seldom sees such a complete treatise on a subject as this is on th *dian Machinery.*

Practical Metal Turning. By Joseph G. Horner.

A work of 404 pages, fully illustrated, covering in a comprehensive manner t tice of machining metal parts in the lathe, including the regular engine la design, its uses, its tools, its attachments, and the manner of holding the wo ing the operations. The modernized engine lathe, its methods, tools and gre rate work. The turret lathe, its tools, accessories and methods of performi Chapters on special work, grinding, tool holders, speeds, feeds, modern Second edition . . . .

Turning and Boring Tapers. By Fred H. Colvin.

There are two ways to turn tapers; the right way and one other. This t with the right way; it tells you how to start the work properly, how to se tools to use and how to use them, and forty and one other little things that Fourth edition . . . .

LIQUID AIR

uid Air and the Liquefaction of Gases. By T. O'Conor Sloane.

This book gives the history of the theory, discovery and manufacture of Liquid Air, and contains an illustrated description of all the experiments that have excited the wonder of audiences all over the country. It shows how liquid air, like water, is carried hundreds of miles and is handled in open buckets. It tells what may be expected from it in the near future.

A book that renders simple one of the most perplexing chemical problems of the century. Startling developments illustrated by actual experiments.

It is not only a work of scientific interest and authority, but is intended for the general reader, being written in a popular style—easily understood by every one. Second edition. 365 pages. Price **$2.00**

LOCOMOTIVE ENGINEERING

Brake Catechism. By Robert H. Blackall.

This book is a standard text-book. It covers the Westinghouse Air-Brake Equipment, including the No. 5 and the No. 6 E.-T. Locomotive Brake Equipment; the K (Quick Service) Triple Valve for Freight Service; and the Cross-Compound Pump. The operation of all parts of the apparatus is explained in detail, and a practical way of finding their peculiarities and defects, with a proper remedy, is given. It contains 2,000 questions with their answers, which will enable any railroad man to pass any examination on the subject of Air Brakes. Endorsed and used by air-brake instructors and examiners on nearly every railroad in the United States. Twenty-sixth edition. 411 pages, fully illustrated with colored plates and diagrams. Price **$2.00**

erican Compound Locomotives. By Fred H. Colvin.

The only book on compounds for the engineman or shopman that shows in a plain, practical way the various features of compound locomotives in use. Shows how they are made, what to do when they break down or balk. Contains sections as follows: A Bit of History. Theory of Compounding Steam Cylinders. Baldwin Two-Cylinder Compound. Pittsburg Two-Cylinder Compound. Rhose Island Compound. Richmond Compound. Rogers Compound. Schenectady Two-Cylinder Compound. Vauclain Compound. Tandem Compounds. Baldwin Tandem. The Colvin-Wightman Tandem. Schenectady Tandem. Balanced Locomotives. Baldwin Balanced Compound. Plans for Balancing. Locating Blows. Breakdowns. Reducing Valves. Drifting. Valve Motion. Disconnecting. Power of Compound Locomotives. Practical Notes.

Fully illustrated and containing ten special "Duotone" inserts on heavy Plate Paper, showing different types of Compounds. 142 pages. Price **$1.00**

plication of Highly Superheated Steam to Locomotives. By Robert Garbe.

A practical book which cannot be recommended too highly to those motive-power men who are anxious to maintain the highest efficiency in their locomotives. Contains special chapters on Generation of Highly Superheated Steam; Superheated Steam and the Two-Cylinder Simple Engine; Compounding and Superheating; Designs of Locomotive Superheaters; Constructive Details of Locomotives Using Highly Superheated Steam. Experimental and Working Results. Illustrated with folding plates and tables. Cloth. Price **$2.50**

nbustion of Coal and the Prevention of Smoke. By Wm. M. Barr.

This book has been prepared with special reference to the generation of heat by the combustion of the common fuels found in the United States and deals particularly with the conditions necessary to the economic and smokeless combustion of bituminous coal in Stationary and Locomotive Steam Boilers.

Presentation of this important subject is systematic and progressive. The arrangement of the book is in a series of practical questions to which are appended accurate answers, which describe in language free from technicalities the several processes involved in the furnace combustion of American fuels; it clearly states the essential requisites for perfect combustion, and points out the best methods of furnace construction for obtaining the greatest quantity of heat from any given quality of coal. Nearly 350 pages, fully illustrated. Price **$1.00**

Diary of a Round-House Foreman. By

This is the greatest book of railroad experienc formation and suggestions along the line of ha afford to miss. 176 pages. Price . . . . . .

Link Motions, Valves and Valve Setting. of "American Machinist."

A handy book for the engineer or machinist t Shows the different valve gears in use, how th of different types are illustrated and explaine motive-power department ought to have. Co Valve Movements, Setting Slide Valves, Anal Block, Slice Valves, Piston Valves, Setting Pist Valve Gear, Gooch Valve Gear, Alfree-Hubbe Price . . . .

Locomotive Boiler Construction. By Fr

The construction of boilers in general is treat is taken up in the order in which its various of boilers used; gives details of construction; p and dies; work done per day, allowance for Including the recent Locomotive Boiler Inspe their answers for Government Inspectors. Co ing and Forging; Punching; Shearing; Plate Bending; Machinery Parts; Riveting; Boile and Calking; Boiler-Shop Machinery, etc., etc. There isn't a man who has anything to do wit doesn't need this book. The manufacturer, all need it. No matter what the type of biole wouldn't be without. Over 400 pages, five lar

Locomotive Breakdowns and their Rem vised by Wm. W. Wood, Air-Brake Inst edition.

It is out of the question to try and tell you abo edition of Locomotive Breakdowns. Just imag may expect to happen some time, and then add occur, but that you have never thought about, a the very best methods of repair. Walschaert Headlight Troubles, as well as Questions and An pages. 8th Revised Edition. Fully illustrated.

Locomotive Catechism. By Robert Gri

The revised edition of "Locomotive Catechism, Cover to Cover. It contains twice as many pa previous editions. Includes the greatest amou the construction and management of modern l the Walschaert Locomotive Valve Gear, the Air- are given.

It commends itself at once to every Engineer a examination or promotion. In plain language, questions asked by the examining engineer are experienced would ask the veteran, and which o Encyclopedia of the Locomotive, is entirely fr thoroughly up to date. Contains over 4,000 825 pages, 437 illustrations, and 3 folding plates.

tical Instructor and Reference Book for Locomotive Firemen and Engineers. By CHAS. F. LOCKHART.

An entirely new book on the Locomotive. It appeals to every railroad man, as it tells him how things are done and the right way to do them. Written by a man who has had years of practical experience in locomotive shops and on the road firing and running. The information given in this book cannot be found in any other similar treatise. Eight hundred and fifty-one questions with their answers are included, which will prove specially helpful to those preparing for examination. Practical information on: The Construction and Operation of Locomotives, Breakdowns and their Remedies, Air Brakes and Valve Gears. Rules and Signals are handled in a thorough manner. As a book of reference it cannot be excelled. The book is divided into six parts, as follows: 1. The Fireman's Duties. 2. General Description of the Locomotive. 3. Breakdowns and their Remedies. 4. Air Brakes. 5. Extracts from Standard Rules. 6. Questions for Examination. The 851 questions have been carefully selected and arranged. These cover the examinations required by the different railroads. 368 pages, 88 illustrations. Price **$1.50**

vention of Railroad Accidents, or Safety in Railroading. By GEORGE BRADSHAW.

This book is a heart-to-heart talk with Railroad Employees, dealing with facts, not theories, and showing the men in the ranks, from every-day experience, how accidents occur and how they may be avoided. The book is illustrated with seventy original photographs and drawings showing the safe and unsafe methods of work. No visionary schemes, no ideal pictures. Just Plain Facts and Practical Suggestions are given. Every railroad employee who reads the book is a better and safer man to have in railroad service. It gives just the information which will be the means of preventing many injuries and deaths. All railroad employees should procure a copy, read it, and do their part in preventing accidents. 169 pages. Pocket size. Fully illustrated. Price .... **50 cents**

in Rule Examinations Made Easy. By G. E. COLLINGWOOD.

This is the only practical work on train rules in print. Every detail is covered, and puzzling points are explained in simple, comprehensive language, making it a practical treatise for the Train Dispatcher, Engineman, Trainman, and all others who have to do with the movements of trains. Contains complete and reliable information of the Standard Code of Train Rules for single track. Shows Signals in Colors, as used on the different roads. Explains fully the practical application of train orders, giving a clear and definite understanding of all orders which may be used. The meaning and necessity for certain rules are explained in such a manner that the student may know beyond a doubt the rights conferred under any orders he may receive or the action required by certain rules. As nearly all roads require trainmen to pass regular examinations, a complete set of examination questions, with their answers, are included. These will enable the student to pass the required examinations with credit to himself and the road for which he works. 2nd Edition, Revised. 256 pages, fully illustrated, with Train Signals in Colors. Price **$1.25**

e Walschaert and Other Modern Radial Valve Gears for Locomotives. By WM. W. WOOD.

If you would thoroughly understand the Walschaert Valve Gear you should possess a copy of this book, as the author takes the plainest form of a steam engine—a stationary engine in the rough, that will only turn its crank in one direction—and from it builds up, with the reader's help, a modern locomotive equipped with the Walschaert Valve Gear, complete. The points discussed are clearly illustrated: Two large folding plates that show the positions of the valves of both inside or outside admission type, as well as the links and other parts of the gear when the crank is at nine different points in its revolution, are especially valuable in making the movement clear. These employ sliding cardboard models which are contained in a pocket in the cover.

The book is divided into five general divisions, as follows: 1. Analysis of the gear. 2. Designing and erecting the gear. 3. Advantages of the gear. 4. Questions and answers relating to the Walschaert Valve Gear. 5. Setting valves with the Walschaert Valve Gear; the three primary types of locomotive valve motion; modern radial valve gears other than the Walschaert; the Hobart All-free Valve and Valve Gear, with questions and answers on breakdowns; the Baker-Pilliod Valve Gear; the Improved Baker-Pilliod Valve Gear, with questions and answers on breakdowns.

The questions with full answers given will be especially valuable to firemen and engineers in preparing for an examination for promotion. 245 pages. 3rd Revised Edition. Price **$1.50**

Westinghouse E-T Air-Brake Instruction Pocket Book. By Wm
Air-Brake Instructor.

Here is a book for the railroad man, and the man who aims to be one. It is the only complete work published on the Westinghouse E-T Locomotive Bra Written by an Air-Brake Instructor who knows just what is needed. It cov thoroughly. Everything about the New Westinghouse Engine and Tender ment, including the standard No. 5 and the Perfected No. 6 style of brake, is t Written in plain English and profusely illustrated with Colored Plates, whic trace the flow of pressures throughout the entire equipment. The best book on the Air Brake. Equally good for the beginner and the advanced engineer. one through any examination. It informs and enlightens you on every point to every engineman and trainman.
Contains examination questions and answers on the E-T equipment. Coverin Brake is. How it should be operated. What to do when defective. Not a asked of the engineman up for promotion, on either the No. 5 or the No. 6 that is not asked and answered in the book. If you want to thoroughly und equipment get a copy of this book. It covers every detail. Makes Air-Bra examinations easy. Price..

MACHINE-SHOP PRACTICE

American Tool Making and Interchangeable Manufacturin
Woodworth.

A "shoppy" book, containing no theorizing, no problematical or experimental are no badly proportioned and impossible diagrams, no catalogue cuts, but tion of drawings and descriptions of devices, the rich fruits of the author's In its 500-odd pages the one subject only, Tool Making, and whatever relate with. The work stands without a rival. It is a complete, practical treati American Tool Making and system of interchangeable manufacturing as car the United States. In it are described and illustrated all of the different ty small tools, fixtures, devices, and special appliances which are in general us manufacturing and metal-working establishments where economy, capacity, ability in the production of machined metal parts are imperative. The scie is exhaustively discussed, and particular attention is paid to drill jigs, bori milling fixtures and other devices in which the parts to be machined are loc within the contrivances. All of the tools, fixtures, and devices illustrated an been or are used for the actual production of work, such as parts of drill presses machinery, typewriters, electrical apparatus, mechanical appliances, brass go parts, mould products, sheet-metal articles, drop-forgings, jewelry, watches, 531 pages. Price..

HENLEY'S ENCYCLOPEDIA OF PRACTICAL ENGINEERING A TRADES. Edited by Joseph G. Horner, A.M.I., M.E.

This set of five volumes contains about 2.500 pages with thousands of illust diagrammatic and sectional drawings with full explanatory details. This entire practice of Civil and Mechanical Engineering. The best known expe of engineering have contributed to these volumes. The Cyclopedia is admir to the needs of the beginner and the self-taught practical man, as well a engineer, designer, draftsman, shop superintendent, foreman, and machinist be found a means of advancement to any progressive man. It is encyclope ough and practical in its treatment on technical subjects, simple and clear matter, and without unnecessary technicalities or formulæ. The articles ar be and yet give a reasonably clear and explicit statement of the subject, a men who have had ample practical experience in the matters of which the you all you want to know about engineering and tells it so simply, so clearly, one cannot help but understand. As a work of reference it is without a set of five volumes, price . . . .

Threads and Thread Cutting. By Colvin and Stabel.

This clears up many of the mysteries of thread-cutting, such as double a internal threads, catching threads, use of hobs, etc. Contains a lot of usef tables. Third edition. Price..

THE WHOLE FIELD OF MECHANICAL MOVEMENTS COVERED BY MR. HISCOX'S TWO BOOKS

We publish two books by Gardner D. Hiscox that will keep you from "inventing" things that have been done before, and suggest ways of doing things that you have not thought of before. Many a man spends time and money pondering over some mechanical problem, only to learn, after he has solved the problem, that the same thing has been accomplished and put in practice by others long before. Time and money spent in an effort to accomplish what has already been accomplished are time and money LOST. The whole field of mechanics, every known mechanical movement, and practically every device are covered by these two books. If the thing you want has been invented, it is illustrated in them. If it hasn't been invented, then you'll find in them the nearest things to what you want, some movements or devices that will apply in your case, perhaps; or which will give you a key from which to work. No book or set of books ever published is of more real value to the Inventor, Draftsman, or practical Mechanic than the two volumes described below.

chanical Movements, Powers, and Devices. By Gardner D. Hiscox.

This is a collection of 1,890 engravings of different mechanical motions and appliances, accompanied by appropriate text, making it a book of great value to the inventor, the draftsman, and to all readers with mechanical tastes. The book is divided into eighteen sections or chapters, in which the subject-matter is classified under the following heads: Mechanical Powers; Transmission of Power; Measurement of Power; Steam Power; Air Power Appliances; Electric Power and Construction; Navigation and Roads; Gearing; Motion and Devices; Controlling Motion; Horological; Mining; Mill and Factory Appliances; Construction and Devices; Drafting Devices; Miscellaneous Devices, etc. 15th Edition. 400 octavo pages. Price $3.00

chanical Appliances, Mechanical Movements and Novelties of Construction. By Gardner D. Hiscox.

This is a supplementary volume to the one upon mechanical movements. Unlike the first volume, which is more elementary in character, this volume contains illustrations and descriptions of many combinations of motions and of mechanical devices and appliances found in different lines of machinery, each device being shown by a line drawing with a description showing its working parts and the method of operation. From the multitude of devices described and illustrated might be mentioned, in passing, such items as conveyors and elevators, Pony brakes, thermometers, various types of boilers, solar engines, oil-fuel burners, condensers, evaporators, Corliss and other valve gears, governors, gas engines, water motors of various descriptions, air ships, motors and dynamos, automobile and motor bicycles, railway lock signals, car couplers, link and gear motions, ball bearings, breech-block mechanism for heavy guns, and a large accumulation of others of equal importance. One thousand specially made engravings. 396 octavo pages. Fourth edition. Price. $3.00

chine-Shop Tools and Shop Practice. By W. H. Vandervoort.

A work of 555 pages and 673 illustrations, describing in every detail the construction, operation and manipulation of both hand and machine tools. Includes chapters on filing, fitting and scraping surfaces; on drills, reamers, taps and dies; the lathe and its tools; planers, shapers, and their tools; milling machines and cutters; gear cutters and gear cutting; drilling machines and drill work; grinding machines and their work; hardening and tempering; gearing, belting and transmission machinery; useful data and tables. Sixth edition. Price. $3.00

chine-Shop Arithmetic. By Colvin-Cheney.

This is an arithmetic of the things you have to do with daily. It tells you plainly about: how to find areas in figures; how to find surface or volume of balls or spheres; handy ways for calculating; about compound gearing; cutting screw threads on any lathe; drilling for taps; speeds of drills; taps, emery wheels, grindstones, milling cutters, etc.; all about the Metric system with conversion tables; properties of metals; strength of bolts and nuts; decimal equivalent of an inch. All sorts of machine-shop figuring and 1,001 other things, any one of which ought to be worth more than the price of this book to you, as it saves you the trouble of bothering the boss. 6th Edition. 131 pages. Price . . . . 50 cents

Modern Milling Machines: Their Desig
By JOSEPH G. HORNER.

This book describes and illustrates the Milling
and forceful manner, and illustrates the subjec
date machinist, student or mechanical enginee
information which it contains. It describes not
their gradual development into the splendid m
and construction of the various types, forms,
manufacturers, American and foreign. 304 page

"Shop Kinks." By ROBERT GRIMSHAW.

A book of 400 pages and 222 illustrations, bei
machine-shop practice. Departing from conv
or common shop usage and limits his work to
more cheaply and more rapidly than usual. A
tative establishments of the world are placed at
the proprietor where large savings are possibl
the employee it holds out suggestions that, pr
No shop can afford to be without it. It bristl
tions. It will benefit all, from apprentice to pro
study its pages. Fifth edition. Price.........

The Modern Machinist. By JOHN T. US

This is a book, showing by plain description a
the work, all that is best, most advanced, and
shop practice, tools and implements, showing t
Maxim says, "American machinists have becom
Indicating as it does, in every line, the familia
experience in the shop, it cannot fail to be of s
the shaping or finishing of metals.
There is nothing experimental or visionary ab
and giving good results. It might be called
variety of special tools and appliances which v
the superintendent down to the man at the b
any machinist's library, and should be consult
done, whether it is boring, milling, turning, or
manner. Fifth edition. 320 pages. 250 illustr

Modern Machine-Shop Construction, E
OSCAR E. PERRIGO.

The only work published that describes the M
time the grass is growing on the site intended fo
the book needed by those contemplating the ere
and reorganization of old ones, or the introduct
systems. It is a book written and illustrated b
who are too busy to read theories and want fac
its kind ever published. Second Edition, Revis
specially made illustrations. 2nd Revised and E

MANUAL TR

Economics of Manual Training. By LOU

The only book published that gives just the inf
Training, regarding Buildings, Equipment, an
for all grades of the work from the Kindergart
itemized lists of everything used in Manual Tr
cost. Also shows where to buy supplies, etc.
Second edition. Price.........................

MARINE ENGINEERING

Naval Architect's and Shipbuilder's Pocket Book of Formulæ, Rules, and Tables and Marine Engineer's and Surveyor's Handy Book of Reference. By CLEMENT MACKROW and LLOYD WOOLLARD.

The eleventh Revised and Enlarged Edition of this most comprehensive work has just been issued. It is absolutely indispensable to all engaged in the Shipbuilding Industry, as it condenses into a compact form all data and formulæ that are ordinarily required. The book is completely up to date, including among other subjects a section on Aeronautics. 750 pages, limp leather binding. Price .... **$5.00 net**

ine Engines and Boilers: Their Design and Construction. By DR. G. BAUER, LESLIE S. ROBERTSON and S. BRYAN DONKIN.

In the words of Dr. Bauer, the present work owes its origin to an oft felt want of a condensed treatise embodying the theoretical and practical rules used in designing marine engines and boilers. The need of such a work has been felt by most engineers engaged in the construction and working of marine engines, not only by the younger men, but also by those of greater experience. The fact that the original German work was written by the chief engineer of the famous Vulcan Works, Stettin, is in itself a guarantee that this book is in all respects thoroughly up-to-date, and that it embodies all the information which is necessary for the design and construction of the highest types of marine engines and boilers. It may be said that the motive power which Dr. Bauer has placed in the fast German liners that have been turned out of late years from the Stettin Works represent the very best practice in marine engineering of the present day. The work is clearly written, thoroughly systematic, theoretically sound; while the character of the plans, drawings, tables, and statistics is without reproach. The illustrations are careful reproductions from actual working drawings, with some well-executed photographic views of completed engines and boilers. 744 pages, 550 illustrations and numerous tables. Cloth. Price .... **$9.00 net**

MINING

Deposits, with a Chapter on Hints to Prospectors. By J. P. JOHNSON.

This book gives a condensed account of the ore deposits at present known in South Africa. It is also intended as a guide to the prospector. Only an elementary knowledge of geology and some mining experience are necessary in order to understand this work. With these qualifications, it will materially assist one in his search for metalliferous mineral occurrences and, so far as simple ores are concerned, should enable one to form some idea of the possibilities of any he may find. Illustrated. Cloth. Price **$2.00**

ctical Coal Mining. By T. H. COCKIN.

An important work, containing 428 pages and 213 illustrations, complete with practical details, which will intuitively impart to the reader not only a general knowledge of the principles of coal mining, but also considerable insight into allied subjects. The treatise is positively up-to-date in every instance, and should be in the hands of every colliery engineer, geologist, mine operator, superintendent, foreman, and all others who are interested in or connected with the industry. 3d Edition. Cloth. Price **$2.50**

ysics and Chemistry of Mining. By T. H. BYROM.

A practical work for the use of all preparing for examinations in mining or qualifying for colliery managers' certificates. The aim of the author in this excellent book is to place clearly before the reader useful and authoritative data which will render him valuable assistance in his studies. The only work of its kind published. The information incorporated in it will prove of the greatest practical utility to students, mining engineers, colliery managers, and all others who are specially interested in the present-day treatment of mining problems. 160 pages, illustrated. Price **$2.00**

PATTERN M

Practical Pattern Making. By F. W. B

This book, now in its second edition, is a compr
subject of pattern making, illustrating pattern w
instructions on the use of plaster of paris in the
tions of the materials used by pattern makers
bench and the more interesting machine tools,
Circular Saw, and the Band Saw. It gives ma
illustrated and explained with much detail. Th
that will be found of interest to all pattern ma
are seeking information on the more advanced
In this second edition of the work will be foun
long practised this exacting trade. In the descr
Machine many difficulties which have long prev
castings are overcome; and this great, new bra
ping plate and stool plate work and the less e
all explained in detail.
Plain, every-day rules for lessening the cost
keeping, a detailed method of marking, appli
plete information showing what the pattern is,
material of which it is made, the number of
pattern safe, all condensed into a most complet
The book closes with an original and practica
patterns. Containing nearly 350 pages and 17

PERFUM

Perfumes and Cosmetics: Their Prepara
ASKINSON, Perfumer.

A comprehensive treatise, in which there has
to the perfumer or manufacturer of toilet pr
handkerchief perfumes, smelling-salts, sachets
care of the skin, the mouth, the hair, cosmetic
also a detailed description of aromatic substan
some manufacture, including a chapter on syn
A book of general as well as professional inte
gist and perfume manufacturer, but also of t
1. The History of Perfumery. 2. About Aro
the Vegetable Kingdom. 4. The Aromatic V
5. The Animal Substances Used in Perfumery.
7. The Extraction of Odors. 8. The Special C
Adulteration of Essential Oils and Their Rec
of Physical Properties of Aromatic Chemical
in Perfumery. 13. Directions for Making t
14. The Division of Perfumery. 15. The Man
mulas for Handkerchief Perfumes. 17. Amm
fumes. 19. Formulas for Dry Perfumes. 20.
tiseptic and Therapeutic Value of Perfumes.
Perfumery Products. 24. Hygiene and Cosme
of the Skin. 26. Manufacture of Casein. 27
Cream. 29. Formulas for Meals, Pastes and
the Hair. 31. Formulas for Hair Tonics a
33. Formulas for the Manufacture of Pomade
tories. 35. Wax Pomades, Bandolines a
Face Lotions. 37. Preparations for the Nails
Preparations for the Care of the Mouth. 40. T
sils Used in the Toilet. Fourth edition, mu
400 pages, illustrated. Price. . . . .

WHAT IS SAID OF

"The most satisfactory work on the subject o
"We feel safe in saying that here is a book o
it has practical and excellent formulæ that are
"We recommend the volume as worthy of con
appointed in securing from its pages good value
even if he should use but one per cent. of its wo

PLUMBING

anical Drawing for Plumbers. By R. M. Starbuck.

A concise, comprehensive and practical treatise on the subject of mechanical drawing in i various modern applications to the work of all who are in any way connected with the plum ing trade. Nothing will so help the plumber in estimating and in explaining work to cu tomers and workmen as a knowledge of drawing, and to the workman it is of inestimab value if he is to rise above his position to positions of greater responsibility. Among tl chapters contained are: 1. Value to plumber of knowledge of drawing; tools required ai their use; common views needed in mechanical drawing. 2. Perspective versus mechanic drawing in showing plumbing construction. 3. Correct and incorrect methods in plumbi drawing; plan and elevation explained. 4. Floor and cellar plans and elevation; sca drawings; use of triangles. 5. Use of triangles, drawing of fittings, traps, etc. 6. Drawi plumbing elevations and fittings. 7. Instructions in drawing plumbing elevations. 8. Tl drawing of plumbing fixtures; scale drawings. 9. Drawings of fixtures and fittings. 10. In ing of drawings. 11. Shading of drawings. 12. Shading of drawings. 13. Sectional drawing drawing of threads. 14. Plumbing elevations from architect's plan. 15. Elevations of sep rate parts of the plumbing system. 16. Elevations from the architect's plans. 17. Drawin of detail plumbing connections. 18. Architect's plans and plumbing elevations of residenc 19. Plumbing elevations of residence (*continued*); plumbing plans for cottage. 20. Plumbi elevations; roof connections. 21. Plans and plumbing elevations for six-flat building. 2 Drawing of various parts of the plumbing system; use of scales. 23. Use of architect's scale 24. Special features in the illustrations of country plumbing. 25. Drawing of wrought-ir piping, valves, radiators, coils, etc. 26. Drawing of piping to illustrate heating system 150 illustrations. Price $1.5

ern Plumbing Illustrated. By R. M. Starbuck.

This book represents the highest standard of plumbing work. It has been adopted and use as a reference book by the United States Government in its sanitary work in Cuba, Por Rico and the Philippines, and by the principal Boards of Health of the United States ar Canada.

It gives connections, sizes and working data for all fixtures and groups of fixtures. It is hel ful to the master plumber in demonstrating to his customers and in figuring work. It giv the mechanic and student quick and easy access to the best modern plumbing practice. Su gestions for estimating plumbing construction are contained in its pages. This book repr sents, in a word, the latest and best up-to-date practice and should be in the hands of eve architect, sanitary engineer and plumber who wishes to keep himself up to the minute c this important feature of construction. Contains following chapters, each illustrated with full-page plate: Kitchen sink, laundry tubs, vegetable wash sink; lavatories, pantry sink contents of marble slabs; bath tub, foot and sitz bath, shower bath; water closets, ventir of water closets; low-down water closets, water closets operated by flush valves, water clos range; slop sink, urinals, the bidet; hotel and restaurant sink, grease trap; refrigerator safe wastes, laundry waste, lines of refrigerators, bar sinks, soda fountain sinks; horse stal frost-proof water closets; connections for S traps, venting; connections for drum trap soil-pipe connections; supporting of soil pipe; main trap and fresh-air inlet; floor drains an cellar drains, subsoil drainage; water closets and floor connections; local venting; connectior for bath rooms; connections for bath rooms, *continued;* examples of poor practice; roughin work ready for test; testing of plumbing systems; method of continuous venting; continuou venting for two-floor work; continuous venting for two lines of fixtures on three or mo floors; continuous venting of water closets; plumbing for cottage house; construction fc cellar piping; plumbing for residence, use of special fittings; plumbing for two-flat hous plumbing for apartment building, plumbing for double apartment building; plumbing fc office building; plumbing for public toilet rooms; plumbing for public toilet rooms, *co tinued;* plumbing for bath establishment; plumbing for engine house, factory plumbin automatic flushing for schools, factories, etc.; use of flushing valves; urinals for public toil rooms; the Durham system, the destruction of pipes by electrolysis; construction of wor without use of lead; automatic sewage lift; automatic sump tank; country plumbin construction of cesspools; septic tank and automatic sewage siphon; water supply fc country house; thawing of water mains and service by electricity; double boilers; h water supply of large buildings; automatic control of hot-water tank; suggestions fc *estimating plumbing construction.* 407 octavo pages, fully illustrated by 57 full-pa *engravings. Third,* revised and enlarged edition, just issued. Price $4

Standard Practical Plumbing. By R. M. Starbuck.

A complete practical treatise of 450 pages, covering the subject of Modern Plu branches, a large amount of space being devoted to a very complete and practic the subject of Hot Water Supply and Circulation and Range Boiler Work. Its include about every phase of the subject one can think of, making it an indispe the master plumber, the journeyman plumber, and the apprentice plumber, c ters on: the plumber's tools; wiping solder; composition and use; joint wipi traps; siphonage of traps; venting; continuous venting; house sewer and sew house drain; soil piping, roughing; main trap and fresh air inlet; floor, yar rain leaders, etc.; fixture wastes; water closets; ventilation; improved plumbi residence plumbing; plumbing for hotels, schools, factories, stables, etc.; n plumbing; filtration of sewage and water supply; hot and cold supply; range b tion; circulating pipes; range boiler problems; hot water for large buildings; its use; multiple connections for hot water boilers; heating of radiation by theory for the plumber; drawing for the plumber. Fully illustrated by 3 Price . . . .

RECIPE BOOK

Henley's Twentieth Century Book of Recipes, Formulas and
Edited by Gardner D. Hiscox.

The most valuable Techno-chemical Formula Book published, including over scientific, chemical, technological, and practical recipes and processes.
This is the most complete Book of Formulas ever published, giving thousand the manufacture of valuable articles for everyday use. Hints, Helps, Practi Secret Processes are revealed within its pages. It covers every branch of the tells thousands of ways of making money, and is just the book everyone sho command.
Modern in its treatment of every subject that properly falls within its scope, truthfully be said to present the very latest formulas to be found in the arts and to retain those processes which long experience has proven worthy of a per To present here even a limited number of the subjects which find a place in this would be difficult. Suffice to say that in its pages will be found matter of inter immeasurably practical value to the scientific amateur and to him who wish knowledge of the many processes used in the arts, trades and manufactur which will render his pursuits more instructive and remunerative. reference book to the small and large manufacturer and supplying intelligent s information necessary to conduct a process, the work will be found of inestir the Metallurgist, the Photographer, the Perfumer, the Painter, the Manufac Pastes, Cements, and Mucilages, the Compounder of Alloys, the Cook, the Druggist, the Electrician, the Brewer, the Engineer, the Foundryman, the Potter, the Tanner, the Confectioner, the Chiropodist, the Manicurist, the M Chemical Novelties and Toilet Preparations, the Dyer, the Electroplater, the Engraver, the Provisioner, the Glass Worker, the Goldbeater, the Watchmak the Hat Maker, the Ink Manufacturer, the Optician, the Farmer, the Dairym Maker, the Wood and Metal Worker, the Chandler and Soap Maker, the Veter and the Technologist in general.
A mine of information, and up-to-date in every respect. A book which will to EVERYONE, as it covers every branch of the Useful Arts. Every home n every office, every factory, every store, every public and private enterprise—EV —should have a copy. 800 pages. Price . . . .

WHAT IS SAID OF THIS BOOK:

"Your Twentieth Century Book of Recipes, Formulas, and Processes duly r glad to have a copy of it, and if I could not replace it, money couldn't buy it. thing of the sort I ever saw." (Signed) M. E. Trux, Sparta, Wis.

"There are few persons who would not be able to find in the book some singl would repay several times the cost of the book."—*Merchants' Record and Show* I

"I purchased your book, 'Henley's Twentieth Century Book of Recipes, Form esses,' about a year ago and it is worth its weight in *gold*."—Wm. H. Murray, Be

"ONE OF THE WORLD'S MOST USEFUL BOOKS"

"Some time ago I got one of your 'Twentieth Century Books of Formulas,' a my living from it ever since. I am alone since my husband's death with two to care for and am trying so hard to support them. I have customers who Toilet Articles I put up, following directions given in the book, and I have fou them to be fine."—Mrs. J. H. McMaken, West Toledo, Ohio.

RUBBER

er Hand Stamps and the Manipulation of India Rubber. By T. O'CONOR SLOANE.

This book gives full details on all points, treating in a concise and simple manner the elements of nearly everything it is necessary to understand for a commencement in any branch of the India Rubber Manufacture. The making of all kinds of Rubber Hand Stamps, Small Articles of India Rubber, U. S. Government Composition, Dating Hand Stamps, the Manipulation of Sheet Rubber, Toy Balloons, India Rubber Solutions, Cements, Blackings, Renovating, Varnish, and Treatment for India Rubber Shoes, etc.; the Hektograph Stamp Inks, and Miscellaneous Notes, with a Short Account of the Discovery, Collection and Manufacture of India Rubber, are set forth in a manner designed to be readily understood, the explanations being plain and simple. Including a chapter on Rubber Tire Making and Vulcanizing; also a chapter on the uses of rubber in Surgery and Dentistry. 3rd Revised and Enlarged Edition. 175 pages. Illustrated **$1.00**

SAWS

Filing and Management of Saws. By ROBERT GRIMSHAW.

A practical hand-book on filing, gumming, swaging, hammering, and the brazing of band saws, the speed, work, and power to run circular saws, etc. A handy book for those who have charge of saws, or for those mechanics who do their own filing, as it deals with the proper shape and pitches of saw teeth of all kinds and gives many useful hints and rules for gumming, setting, and filing, and is a practical aid to those who use saws for any purpose. Complete tables of proper shape, pitch, and saw teeth as well as sizes and number of teeth of various saws are included. 3rd Edition, Revised and Enlarged. Illustrated. Price **$1.00**

STEAM ENGINEERING

erican Stationary Engineering. By W. E. CRANE.

This book begins at the boiler room and takes in the whole power plant. A plain talk on every-day work about engines, boilers, and their accessories. It is not intended to be scientific or mathematical. All formulas are in simple form so that any one understanding plain arithmetic can readily understand any of them. The author has made this the most practical book in print; has given the results of his years of experience, and has included about all that has to do with an engine room or a power plant. You are not left to guess at a single point. You are shown clearly what to expect under the various conditions; how to secure the best results; ways of preventing "shut downs" and repairs; in short, all that goes to make up the requirements of a good engineer, capable of taking charge of a plant. It's plain enough for practical men and yet of value to those high in the profession.

A partial list of contents is: The boiler room, cleaning boilers, firing, feeding; pumps, inspection and repair; chimneys, sizes and cost; piping; mason work; foundations; testing cement; pile driving; engines, slow and high speed; valves; valve setting; Corliss engines, setting valves, single and double eccentric; air pumps and condensers; different types of condensers; water needed; lining up; pounds; pins not square in crosshead or crank; engineers' tools; pistons and piston rings; bearing metal; hardened copper; drip pipes from cylinder jacket; belts, how made, care of; oils; greases; testing lubricants; rules and tables, including steam tables; areas of segments; squares and square roots; cubes and cube root; areas and circumferences of circles. Notes on: Brick work; explosions; pumps; pump valves; heaters, economizers; safety valves; lap, lead, and clearance. Has a complete examination for a license, etc., etc. 3rd Edition. 345 pages, illustrated. Price **$2.00**

sepower Chart.

Shows the horsepower of any stationary engine without calculation. No matter what the cylinder diameter of stroke, the steam pressure of cut-off, the revolutions, or whether condensing or non-condensing, it's all there. Easy to use, accurate, and saves time and calculations. Especially useful to engineers and designers. Price . . . . **50 cents**

STEAM HEATING AND VENTILATION

ctical Steam, Hot-Water Heating and Ventilation. By A. G. King.

This book is the standard and latest work published on the subject and has been prepared for the use of all engaged in the business of steam, hot-water heating, and ventilation. It is an original and exhaustive work. Tells how to get heating contracts, how to install heating and ventilating apparatus, the best business methods to be used, with "Tricks of the Trade" for shop use. Rules and data for estimating radiation and cost and such tables and information as make it an indispensable work for everyone interested in steam, hot-water heating, and ventilation. It describes all the principal systems of steam, hot-water, vacuum, vapor, and vacuum-vapor heating, together with the new accelerated systems of hot-water circulation, including chapters on up-to-date methods of ventilation and the fan or blower system of heating and ventilation. Containing chapters on: I. Introduction. II. Heat. III. Evolution of artificial heating apparatus. IV. Boiler surface and settings. V. The chimney flue. VI. Pipe and fittings. VII. Valves, various kinds. VIII. Forms of radiating surfaces. IX. Locating of radiating surfaces. X. Estimating radiation. XI. Steam-heating apparatus. XII. Exhaust-steam heating. XIII. Hot-water heating. XIV. Pressure systems of hot-water work. XV. Hot-water appliances. XVI. Greenhouse heating. XVII. Vacuum vapor and vacuum exhaust heating. XVIII. Miscellaneous heating. XIX. Radiator and pipe connections. XX. Ventilation. XXI. Mechanical ventilation and hot-blast heating. XXII. Steam appliances. XXIII. District heating. XXIV. Pipe and boiler covering. XXV. Temperature regulation and heat control. XXVI. Business methods. XXVII. Miscellaneous. XXVIII. Rules, tables, and useful information. 367 pages, 300 detailed engravings. 2nd Edition—Revised. Price **$3.00**

e Hundred Plain Answers to Direct Questions on Steam, Hot-Water, Vapor and Vacuum Heating Practice. By Alfred G. King.

This work, just off the press, is arranged in question and answer form; it is intended as a guide and text-book for the younger, inexperienced fitter and as a reference book for all fitters. This book tells "how" and also tells "why". No work of its kind has ever been published. It answers all the questions regarding each method or system that would be asked by the steam fitter or heating contractor, and may be used as a text or reference book, and for examination questions by Trade Schools or Steam Fitters' Associations. Rules, data, tables and descriptive methods are given, together with much other detailed information of daily practical use to those engaged in or interested in the various methods of heating. Valuable to those preparing for examinations. Answers every question asked relating to modern Steam, Hot-Water, Vapor and Vacuum Heating. Among the contents are: The Theory and Laws of Heat. Methods of Heating. Chimneys and Flues. Boilers for Heating. Boiler Trimmings and Settings. Radiation. Steam Heating. Boiler, Radiator and Pipe Connections for Steam Heating. Hot Water Heating. The Two-Pipe Gravity System of Hot Water Heating. The Circuit System of Hot Water Heating. The Overhead System of Hot Water Heating. Boiler, Radiator and Pipe Connections for Gravity Systems of Hot Water Heating. Accelerated Hot Water Heating. Expansion Tank Connections. Domestic Hot Water Heating. Valves and Air Valves. Vacuum Vapor and Vacuo-Vapor Heating. Mechanical Systems of Vacuum Heating. Non-Mechanical Vacuum Systems. Vapor Systems. Atmospheric and Modulating Systems. Heating Greenhouses. Information, Rules and Tables. 200 pages, 127 illustrations. Octavo. Cloth. Price **$1.50**

STEEL

rdening, Tempering, Annealing, and Forging of Steel. By J. V. Woodworth.

A new work treating in a clear, concise manner all modern processes for the heating, annealing, forging, welding, hardening and tempering of steel, making it a book of great practical value to the metal-working mechanic in general, with special directions for the successful hardening and tempering of all steel tools used in the arts, including milling cutters, taps, thread dies, reamers, both solid and shell, hollow mills, punches and dies, and all kinds of sheet-metal working tools, shear blades, saws, fine cutlery, and metal-cutting tools of all description, as well as for all implements of steel both large and small. In this work the simplest and most satisfactory hardening and tempering processes are given.

The uses to which the leading brands of ste
their treatment for working under different
for the hardening and tempering of special b
A chapter devoted to the different processes
reference made to the adaptation of machin
tion. 288 pages. 201 illustrations. Price .

Steel: Its Selection, Annealing, Har
MARKHAM.

This work was formerly known as "The A
of the new, revised edition, the publishers d
suitable one. It is the standard work on Hard
This book tells how to select, and how to w
thing on earth. It doesn't tell how to tempe
of another kind of tool to your imagination
for every detail of every tool, whether it be
about the tempering of small watch springs
dies. In fact, there isn't a thing that a steel
It is the standard book on selecting, harde
the chapter headings might be mentioned t
man; steel; methods of heating; heating t
baths for hardening; hardening steel; dra
hardening; pack hardening; case hardenin
steel; special steels; steel for various tools;
pages. Very fully illustrated. Fourth edition

TRACT

The Modern Gas Tractor. By VICTOR

A complete treatise describing all types and
siders design and construction exhaustively,
and repair, outlines all practical applicatio
latest work on farm tractors and tractor pow
blacksmiths, mechanics, salesmen, implement
revised and enlarged. 504 pages. Nearly 30

TURBI

Marine Steam Turbines. By DR. G.
E. LUDWIG and H. VOGEL.

Translated from the German and edited by
tical and discusses turbines in which the fu
of separate turbines arranged for driving tw
turbines in which the complete expansion o
a turbine on one shaft, as in the case of th
carry out all the ordinary calculation necess
it fills a want which is hardly met by larger
curves and diagrams will be found, which e
turbine blades are designed as they are, th
various types, the thermodynamics of ste
on steam consumption of steam turbines,
signer and builder of steam turbines most
and containing eighteen tables, including

WATCH MAKING

tchmaker's Handbook. By CLAUDIUS SAUNIER.

No work issued can compare with this book for clearness and completeness. It contains 498 pages and is intended as a workshop companion for those engaged in watch-making and allied mechanical arts. Nearly 250 engravings and fourteen plates are included. This is the standard work on watch-making. Price **$3.00**

WELDING

tomobile Welding with the Oxy-Acetylene Flame. By M. KEITH DUNHAM.

Explains in a simple manner apparatus to be used, its care, and how to construct necessary shop equipment. Proceeds then to the actual welding of all automobile parts, in a manner understandable by every one. *Gives principles never to be forgotten.* Aluminum, cast iron, steel, copper, brass, bronze, and malleable iron are fully treated, as well as a clear explanation of the proper manner to burn the carbon out of the combustion head. This book is of utmost value, since the perplexing problems arising when metal is heated to a melting point are fully explained and the proper methods to overcome them shown. 167 pages, fully illustrated. Price **$1.00**

6249

[redacted]


THE UNIVERSITY OF MICHIGAN
1817
M